EDITORIAL

WATER-SUPPLY problems are of great importance in arid or semi-arid regions. When the climate is such that freezing temperatures must be considered, the problem is a particularly difficult one to meet and calls for a high degree of engineering skill in its solution. In another column we print an article by Mr. J. A. Burgess on the water-system for the Nevada Wonder mine. This system cost $60,000 all told, the pipe-line alone costing $41,000. Some of the devices in use we believe would also be of value in irrigation and hydro-electric systems in cold climates.

BEGINNING with our June number, Mr. Henry D. Dewell will contribute a series of articles on 'Timber Framing.' This is a subject on which there is very little authoritative information, such matters being too often left to the 'boss-carpenter,' who does the best he can under the circumstances, but can hardly be expected to have much technical knowledge. Mr. Dewell was connected with the engineering staff of the Panama-Pacific Exposition throughout the entire period of construction, and thus had an opportunity to assist in the design of some of the largest wooden structures ever erected. All those who are concerned with the construction of wooden buildings will be interested in Mr. Dewell's articles.

REMOVAL of the New York headquarters of the American Society of Civil Engineers to the building of the United Engineering Societies has been submitted to the members of the Society for a letter-ballot vote. It will be remembered that when the United Societies building was proposed thirteen years ago, the members of the Society of Civil Engineers decided against joining the other three national engineering societies in occupying the building. At that time there was some apprehension that the individual societies would lose their identity in case they were all under one roof. Experience has proved that this fear was groundless. The main questions, however, are whether or not greater co-operation among the engineering societies is desirable, and whether or not such co-operation will be assisted by having the headquarters of all the engineering societies in the same building. We believe that an affirmative answer should be given to both these questions.

PREPAREDNESS has been advanced a step by the appointment of a Board of 250 engineers selected from all parts of the country to co-operate in a survey of national resources available for military and naval purposes. These representatives of the five national engineering societies will act for a total membership of 30,000. The California members of the Board are Messrs. Wynn Meredith, G. W. Dickie, Charles W. Merrill, A. H. Babcock, and Edmund O'Neill. That members of the engineering profession should have been selected to have entire charge of this work is at once a tribute to engineers in general and an evidence of the sagacity of the Federal officials. Modern warfare is more a matter of supplies than of personal bravery. Allah may not fight on the side of the heaviest battalions, but he certainly seems to have a strong preference for the army that possesses the heaviest munition-trains. While the present War has shown that even typewriter and sewing-machine factories can eventually be remodeled to make shrapnel, it should be remembered that there would be no time for costly experiments should this country be invaded. It is therefore important that we should know what we can do, and be ready to do it, should the necessity arise.

THERE is a close bond existing between engineering and the so-called natural sciences. The telephone company at Canton, Illinois, found it necessary to lay a cable in a long conduit of small diameter. The well-known expedient of tying a fishline to a rat's tail was tried, but either the Canton rats are members of the I. W. W. or the cold, dark conduit was uninviting; at any rate the rats could not be induced to make the trip without urging. This was done by the introduction of a ferret to stimulate the efforts of the rat. Unfortunately, the indolence of rats failed to co-ordinate with the vigorous pursuit of the ferret, which could catch the rat and kill him before the appointed task was completed. Although rat after rat was sent into the conduit, the management found itself unable to estimate the proper handicap for the ferret. Finally, a close student of rat nature proposed to put a bell on the rat and dispense with the ferret. The belled-rat did not stop and carried the line to the end of the conduit. As a reward for his signal services to the community, he was granted those greatest of all blessings, life and liberty.

SALT WATER in oil formations has always been considered an unmitigated nuisance. Carelessness in letting 'top' or 'bottom' water into the oil sand is a source of great expense and loss, while the rise of the water in the oil formation itself as the oil is exhausted, is the last stage in the life of every field. Nevertheless, brine-wells are paying in many parts of the world, and an article in the *Oil City Derrick* suggests that with a well already drilled for oil, the accompanying water might be induced to yield valuable by-products. The War has brought forcibly to our attention the need for a number of chemicals, many of which are known to be

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present in the water produced from oilwells. Whether they are to be found in such amounts as to make recovery commercially profitable is a matter for further investigation. In this connection it may be remarked that most of the California fields are situated where climatic conditions would be favorable to evaporative processes. We may yet see the oil operators not only saving the water that they are obliged to pump with their oil, but also going back to abandoned fields and perforating the casing in old wells at the points where the 'logs' show water-bearing strata.

The Removal of Mr. L. N. Nishkian

In another column we publish a report of the action of the San Francisco Association of Members of the American Society of Civil Engineers regarding the removal of Mr. L. H. Nishkian from his position as structural engineer for the department of building permits of this city, also a letter giving the opinion of a prominent structural engineer upon the matter. Whatever may have been the motive of the Board of Public Works in relieving Mr. Nishkian from his duties, the result is most unfortunate. It is a well-known fact that in most cases, an engineer in public employment cannot expect to receive as much for his services as if he were in private practice or working for a corporation. That this is outweighed in the minds of many engineers by the greater opportunities for public service in government employment is evidenced by the great number of able engineers who are working for some governmental agency. It is also true that public work is usually more continuous than private employment, and now that civil service laws have become generally applied, the usually greater certainty of tenure has proved an additional incentive for engineers to enter public employment. In the case under discussion, however, we have a city employee who, in the judgment of the leading structural engineers of the city was doing excellent and valuable work, and who was removed from his position, almost without warning. How can the City of San Francisco hope to retain competent engineers in its service if their tenure of office is not secure?

Another aspect of this incident deserves mention. So far as we know, the action taken by the local Association of Members of the American Society of Civil Engineers is the first time that a local technical body has taken a definite stand on a public question or on a matter directly affecting one of its members. For many years the work of an engineering society, whether local or national, seemed to be concerned mainly with the reading of technical papers, the preparation of standard specifications, and similar functions. This is not to be understood as a criticism of these functions, which probably will remain as the most important for any technical organization. In recent years, however, there has been a strong feeling that the engineering societies should concern themselves with such public questions as have an engineering aspect, which most public questions have, and also that the welfare of the individual member should receive more attention.

Is the Requirement of a Pavement Guarantee Advisable?

Several good recommendations and one that is extremely doubtful were made by the grand jury of Sacramento county regarding highway construction. The use of permanent construction and the appointment of a trained highway engineer to have entire charge of road-work throughout the county are among the good recommendations. The doubtful one is that contractors should be required to furnish a five-year guarantee of the pavement laid by them.

The origin of the custom of guaranteeing pavement is obscure, but it probably arose when asphalt as a paving material was new and the public in general was doubtful as to its durability. At that time it was often necessary for a contractor who wished to have asphalt adopted to agree to keep the pavement in repair for a given length of time. As time went on, other new paving materials were introduced and guarantees were required for them also. Even though it may have seemed necessary in the case of an untried paving material, the guarantee system was far from satisfactory. The proper way to maintain pavement as to maintain almost anything else is "Little by little, day by day." Unless the city forces are hopelessly inefficient, this can be done better and cheaper by them than by the contractor, who may be engaged in another State by the time maintenance becomes necessary. It happens frequently that while the life of a pavement is all too short, a contractor's business existence and legal responsibility is often shorter, and the city may find the guarantee valueless.

Injustice is done to the contractor when the traffic on the pavement changes in amount or character during the life of the guarantee. In a rapidly growing town it is not unusual for a residence street with light traffic to change in a few years to a business or industrial street with heavy traffic. In such a case it is manifestly absurd to expect the pavement, which was once entirely suitable, to stand up under the increased traffic, or to require the contractor to maintain the pavement in case the guarantee has not yet expired.

At the present time, when paving materials and methods have become fairly standardized, the engineer in charge who insists upon careful inspection, knows as much about what may be expected from a given pavement as the contractor who laid it. The contractor bidding in good faith, who is required to guarantee his pavement must add to his bid on this account a larger amount than would be needed to maintain the pavement by the municipal or county forces. It is probable therefore that the requirement of a pavement guarantee will in almost every case result in a direct financial loss to the municipality, county, or State in which the work happens to be done. New paving materials are likely to appear from time to time, and the experimental use of these should be safeguarded in some way, but it is poor policy to require a guarantee on pavement of an established type laid by a reputable contractor.

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REVIEW OF THE MONTH

THE Panama Canal was reopened on April 15 to vessels of less than 30-foot draft and it is probable that this limitation will be removed before long. It is hardly likely, however, that the Pacific Coast will feel any immediate benefit. Ocean freight rates have risen to such an extent that it is probable that a ship-owner can make more money in the overseas trade than he possibly could in traffic by way of the Canal. Until the War is over, it may safely be said that the railroads will carry practically all transcontinental freight.

ELECTRIFICATION of the Chicago, Milwaukee, & St. Paul system is progressing. At present the line from Harlowton to Deer Lodge, Montana, a distance of 226 miles is electrified. A large part of this distance was under electric operation all last winter. The weather was unusually severe and interfered seriously with the operation of the steam locomotives but the electric locomotives came through with flying colors. When the entire 440 miles in the original plan is electrified it is estimated that there will be a saving in operating expense of about $700,000 annually over steam.

REORGANIZATION of the People's Water Company seems to be as far away as ever. The main difficulty lies in trying to decide whether the stockholders are to get anything at all, or whether the bondholders are to take everything and pocket some loss at that. The plan recommended by the State Railroad Commission provided for the payment of $400,000 in cash to the stockholders in case the system is sold, or a similar amount in bonds if the company is reorganized. While some of the bondholders are willing that this should be done, there is a strong faction opposed to any surrender of rights on the part of the bondholders. Should this faction be successful, a receivership with its attendant delays would seem to be inevitable. The mayors of Oakland and the other east-bay cities have decided not to take any steps toward the formation of a water district and the purchase of the property of the company. It will be remembered that a similiar proposition failed to receive the approval of the voters two years ago, and the officials probably felt that there was no reason to believe that public sentiment had changed materially since. However, ownership either by a water district or by a stronger private company would seem to be the only satisfactory solution of the east-bay water problem. The last few seasons have been characterized by a rainfall above normal but this should not deceive the public as to the need for a really adequate water supply. Whether such a supply can be developed from the property of the People's Water Company remains to be seen.

OIL production for March shows an increase of 19,000 barrels per day over the February figures, indicating that the damage from the January storms has been entirely repaired. Shipments have also increased considerably and stocks were drawn upon to the extent of about one million barrels during the month. While drilling is much more active than a few months ago, the high price of casing and other steel products used in the fields, together with the generally cautious attitude of those who hold the purse-strings has tended to restrict development. It is therefore probable that demand will exceed supply for some time to come. The natural result is a continued increase in prices of both crude oil and refined products. The Standard Oil Company has announced another increase in prices at the well, bringing the price of fuel oil in the San Joaquin valley fields to 58 cents per barrel, with proportional increases for the other grades.

THE Independent Oil Producers' Agency has decided to construct a small refinery for producing gasoline by the Rittman process. It is true that the beginning is small, the amount appropriated being only $25,000, which it is estimated will be sufficient for a plant treating 100 barrels per day. However, it is the expressed intention to construct other plants if this one proves to be a success, which is reasonably certain now that the pioneer work has been done by the Federal Bureau of Mines and the Aetna Explosives Company. It seems fairly well assured that over 50 per cent of gasoline can be recovered from low gravity Kern River oil, and proportionally more from the lighter oils. There is more hope in these figures for the man who desires moderate-priced gasoline than in all the investigating committees that may be appointed by our various legislative bodies in answer to the bitter cry of their constituents.

MEANWHILE the possibility of actually running their properties at a profit is commencing to loom up before the oil producers. Many of them are talking of "Dollar oil in 1917," by which is meant the price of fuel oil per barrel at the well in the San Joaquin valley fields. This may sound improbable but so would 58 cents for the same oil a year ago. If it should come to pass, we suppose that there will be many investigations and hints of deep, dark plots, but for our own part, we do not see why the oil producer should continue to make a present of his time and energies to the general public in order that they may have a useful commodity for far less than either its cost or its real value. In the twenty years since the rise of the old Los Angeles City field, the oil industry has been of incalculable benefit to Cali-

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fornia and to the Pacific Coast. As far as crude oil is concerned most of the consumers of fuel oil can well afford to pay a considerably higher price than that which has ruled during the past few years. It will be many years, if ever, before the price even approximates that of coal. As the price increases, many who are now burning oil will find it advisable to use hydro-electric power, thus furthering real conservation. The same is true with regard to the users of the lower grade of distillates. The gradual adoption of the Rittman process may check the rise in the price of gasoline and even reduce it eventually. Lubricating oil made from California petroleum is still a comparatively new product, although it has already been proved to be equal or superior to that manufactured in other parts of the country. However, the price of crude oil is a comparatively small factor in determining the price of lubricants and it is hardly likely that there will be such an increase in the price of crude as to cause serious inconvenience to lubricant users. The oil producer deserves a fair price for his oil. Here's hoping that he gets it!

UNREGULATED competition in the hydro-electric field by a municipally-owned utility seems likely to cause a large amount of unnecessary expense to Los Angeles taxpayers. It will be remembered that the general plan of the Los Angeles Aqueduct includes the use of the water to generate electric power to be used within the city. For a distribution system the city sought before the State Railroad Commission to condemn the system of the Southern California Edison Company. Disagreements developed regarding physical valuation but the most serious difference appeared in the estimate of severance damages. The Edison company has sought to increase its load factor by sale of power for pumping and other daytime uses. The sale of its city distribution system would involve giving up most of its lighting business and, consequently a considerable reduction in the load factor of the entire system. Furthermore the company has invested large amounts in the generating and transmitting equipment needed to take care of its entire business. If about half that business is taken away from it, this equipment must remain idle until a market for the power can be developed elsewhere—a matter of years. For these reasons, the Company asked for an amount that was several times the mere physical value of that part of its system that the city wished to acquire. The city authorities apparently had little hope of obtaining the Company's system for the price that they wished to pay, since they have commenced to construct a distribution system of their own. There is no contention on the part of anyone that the privately-owned systems are not entirely adequate to serve the community. It is simply a question of spending millions of dollars of the people's money on a needless duplication of existing systems. What makes this course particularly absurd is the fact that the power companies have offered to purchase energy from the City at a fair price. It is no wonder that a committee of citizens has been formed to protest against the whole scheme of duplication.

COMMERCIAL interests in Los Angeles and the surrounding country realize that floods cost more than flood-control, and are considering the initial steps toward securing the latter in the best way possible. The Associated Chambers of Commerce held a joint meeting at Santa Ana a few weeks ago, at which Mr. F. H. Olmsted suggested what appears to us to be the most rational way for attacking the problem. Floods, as well as other ailments that affect the well-being of the human race, ought to be attacked at their sources. Levees are inefficient, and are given to failure at the time when they are most needed. Means for retarding floods should be taken in order to prevent the crest from the heavy fall back in the mountains from reaching the level lands in the valleys at the same time as the crest of the flood from the lower portions of the mountainous territory. Mr. Olmsted called attention to the successful results through the installation of retarding dams in Haines canyon and Western Empire gulch. He suggested the construction of a channel not less than 1000 feet, and co-operation with the Federal Government. Capt. C. T. Leeds, engineer for the Orange County Harbor Commission, endorsed the recommendations of Mr. Olmsted. It is hoped that the sound common sense of the plan offered by Messrs. Olmsted and Leeds will appeal to the people of Los Angeles county, and steps be taken during the 1916 construction season to prevent a repetition of last winter's disaster.

THE total oil production for California for 1915 has just been determined, from the sworn statements made to the State Mineralogist by all of the 363 producers. It amounted to 88,240,620 barrels. This is doubtless the most accurate figure that has even been obtained and it is interesting to note that it is in close agreement with the figures given to the public at an earlier date by two private concerns, namely, the Standard Oil Company and the Independent Oil Producers Agency. Of the total, 33% or 29,587,163 barrels was produced by the five large refining and marketing companies, and 16% or 13,704,982 barrels was produced by the several large concerns, such as the railroad companies, who use the oil in their own service. The remaining 51% or 44,948,475 barrels is credited to the smaller producers, who usually sell the crude oil at the well. The oil comes from eight different counties, the largest amount being from Kern county with 53,041,069 barrels and 3873 producing wells, while second on the list is Fresno county with 13,641,325 barrels and 830 wells, and third place falls to Orange county with 12,535,457 barrels and 414 wells. The remaining counties in order are: Santa Barbara, 5,450,534 barrels and 403 wells; Los Angeles, 2,673,598 barrels and 564 wells; Ventura, 872,020 barrels and 318 wells; Santa Clara, 16,617 barrels and 7 wells; and San Luis Obispo, 10,000 barrels and 3 wells. The natural gas which was marketed has also been computed, there being a total of 14,902,000,000 cubic feet, over 90% of which was from Kern county. The conservation of this important resource is being studied by the State Mining Bureau.

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DISCUSSION

Cause of the Otay Dam Failure

The Editor:

Sir—The writer was at the site of the Lower Otay dam (not in professional capacity) in August, 1893, at which time the excavation had been completed to bedrock and the placing of concrete was about to begin. At that time, as far as the writer is aware, no other type of dam was under consideration than a gravity type of concrete or rubble masonry. There was no question about the foundation except in the matter of a longitudinal seam filled with gouge material which had been uncovered in the very bottom of the foundation pit and showed a width of about 2½ or 3 feet. The gouge material is compact though soft enough to be cut with a knife. It fills the seam which apparently stands nearly vertical. The writer is not advised whether a suggestion volunteered by him that a shaft be sunk between hanging and footwalls for exploration purposes, and subsequently filled with concrete, was carried out or not. At any rate nothing is known to the writer of any trouble from leakage along this seam and the appearance of the seam certainly indicated that none would be likely. The failure of the dam is not to be ascribed to the type adopted later. The failure was due to overtopping, which would not have occurred if the spillway had been adequate. The core-wall was overtopped—no one seems to know to what depth—and the overflow began to tear away the downstream supporting fill, whereupon the core-wall gave way at about the middle of the structure.

It must be concluded from this fact, that the failure of this dam should not be used as a proof of the insufficiency of the type which in consequence of the failure is being more seriously questioned than ever before.

San Francisco, April 24. C. E. GRUNSKY.

The Proposed Engineer Corps of California

The Editor:

Sir—A general plan of organization has been perfected which provides for a civilian volunteer reserve brigade of engineers for California, to be commanded and instructed by specially qualified engineers; retired U. S. Engineer Officers, also graduates of West Point and Annapolis. The organization chart provides for one officer of the Engineer Corps, U. S. A., as advisory head, or Inspector-Instructor, and the following temporary appointments have been made:

William Cushing Hammatt, San Francisco, Member American Society of Civil Engineers, graduate of West Point U. S. Military Academy, Colonel 1st Regiment.

George L. Dillman, San Francisco, Member American Society of Civil Engineers, graduate of Annapolis U. S. Naval Academy, Colonel 2nd Regiment.

Charles Tileston Leeds, Los Angeles, Member American Society of Civil Engineers, Captain of Engineers U. S. Army (retired), Colonel 3rd Regiment.

Joseph D. Smedberg, Oakland, of the State Engineering Department, Brigade Adjutant.

The State has been divided into three sections and one regiment of eight companies provided for each section between Eureka and San Diego. This will remain a civilian engineer organization, patterned in formation, equipment, and instruction, after that of a military Engineer Corps ultimately prepared to volunteer its services in case of need. Training will not interfere with private business and will follow, as much as possible, instructions as approved by U. S. A. Engineer Officers. During the coming year, at least, resignations will be accepted promptly, in case it is found advisable to give up the work.

Company headquarters have been made and recruiting officers appointed, to whom application for volunteer enrollment may be made by engineers, as follows:

Co. A San Francisco	W. C. Hammatt
Co. B " "	A. E. Chandler
Co. C " "	H. W. Crozier
Co. D " "	S. L. G. Knox
Co. E Sacramento	Frank L. Milne
Co. F "	Frank Conrick
Co. G Grass Valley	Joseph A. Kitts
Co. H Eureka	W. H. Holcomb
Co. I Oakland	Jules E. Hanique
Co. J Berkeley	M. H. Peck
Co. K Alameda	J. W. Swaren
Co. L Palo Alto	Andrew Swickard
Co. M San Jose	H. C. Darling
Co. N Stockton	J. P. Spooner, Jr.
Co. P Merced	Grant H. Nickerson
Co. Q Fresno	B. J. Pardee
Co. R Bakersfield	(None at present)
Co. S San Luis Obispo	Albert A. Peters
Co. T Santa Barbara	S. H. Phelan
Co. U Los Angeles	Wilbur Jurden
Co. V " "	D. A. White
Co. W Santa Ana	A. S. Ralph
Co. X Riverside	W. H. Waugh
Co. Y San Diego	L. R. Johnson

These companies will have senior and junior grade engineers (civil, mechanical, electrical, mining and chemical) as commissioned and non-commissioned officers. General instruction in military engineering and infantry tactics will be given the officers preparatory to recruiting for the enlisted grade, which grade will not be recruited at present. Colonel Rees, Chief of Engineers, U. S. A., Western Department, San Francisco, believes the Brigade will become most valuable if a thorough course of instruction in the science of military engineering be first given the officers, after which recruiting of men from the trades of skilled labor, contractors, organizations, etc., will begin.

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Field searchlight operation, placing of barbed-wire entanglements, trenches, pontoon bridges, topographical maps, military roads, protection works for artillery, and mobilization, are some of the items of training to be considered in the formation and school of instruction, in addition to the U. S. Infantry Drill Regulations. This work will be taken up by correspondence, by formation of small squads and companies, and possibly by annual maneuvers with the entire corps, also by personal study of prescribed lectures and text books. The Corps will endeavor to have a squad, or more, in every town of the State where at least two engineers reside. It is hoped that every engineer will assist to stimulate interest in military affairs at this time. Permanent officers have not been selected and will not be until returns are at hand.

The preliminary object is to prepare engineers to operate efficiently in time of necessity, also to study the science of military engineering from a practical standpoint of local requirements. The ultimate result will be a complete corps of engineers ready for service, except such men as may be required by the War Department to remain on duty in the manufacture of munitions of war; such vacancies would be quickly filled by transfer or by recruits. The questions of qualification, appointment and promotion of officers, method of instruction, and co-operation of U. S. Army Headquarters, are being solved. Chamber of Commerce committees will at once be appointed in each city having company headquarters, to assist in the matter of uniforms, equipment, and headquarters for the men, as the organization must for the present be self-supporting.

There will be no conflict between this, the recognized Engineer Corps of California, and any other organization which may possibly be formed later, nor will there be conflict with pending legislation in Washington. The Engineer Corps of California will send a company of engineers to join the U. S. Army Camp at Monterey for instruction in practical work, July 10 to August 5. Application should be made at once to the Adjutant, 5558 Taft avenue, Oakland, or to U. S. A. headquarters, San Francisco, by members who desire this special training by army officers.

San Francisco, April 26. J. W. SWAREN.

Effect of Check-Dams on Stream-Flow

The Editor:

Sir—Check-dams for the purpose of reducing the maximum flood flow of the stream on which built, have the effect of increasing the amount of water which at times of maximum flow may be regarded as in storage. Their effect can be determined in advance with some degree of precision when the increase of channel storage which they make possible can be ascertained. Where comparatively small watersheds are under consideration the storage at each check-dam in excess of channel storage under natural conditions may be treated as though it were a part of one large reservoir. If, now, the mass curve of the flow to the stream from its watershed, as it would be if there were no check-dams, be plotted and at the time of maximum run-off the storage be assumed to be also at a maximum, it will be possible to approximate the resulting decreased maximum discharge. There will be few cases where this method of procedure* will not disclose whether or not the check-dams on any stream are worth while, provided, always, that fair preliminary information is available relating to the stream flow under natural conditions.

San Francisco, April 24. C. E. GRUNSKY.

Removal of Leon H. Nishkian

The Editor:

Sir—The removal of Mr. Leon H. Nishkian as structural engineer from the department of building permits of the Board of Public Works of the city and county of San Francisco is a great loss to the owners and builders of this city. During his term of office, Mr. Nishkian has saved the amount of his salary to the taxpayers many times over, by making every architect, engineer, and builder follow the building ordinances. He knew no friends and had no favorites. Everybody received the same treatment. Every architect and engineer who came in contact with him will testify to these statements.

San Francisco, April 24. M. C. COUCHOT.

TOPOGRAPHIC AND GEOLOGICAL SURVEYS IN ALASKA

Of the total area of approximately 588,000 square miles in Alaska, exploratory geological surveys have been made of 73,200 square miles. These are on a scale of either ten or sixteen miles to the inch. Reconnaissance surveys have been made of 83,735 square miles. These are on a scale of four miles to the inch. Detailed surveys have been made of 4396 square miles, on a scale of one mile to the inch. Exploratory topographic surveys have been made of 51,680 square miles, reconnaissance surveys of 126,880 square miles, and detailed surveys of 3652 square miles. All this work has been done by the United States Geological Survey.

The welding of metals requires the use of a suitable flux to eliminate oxide between the faces of the two parts welded. Wrought iron is welded more easily than steel; the iron may be so hot that small globules fall off or it throws sparks in the forge, while steel will not stand so much heat without burning. The welding point of steel is generally judged to be when it seems wet or oily on the surface. Thermit welding, for heavy work, employs the heat generated by the chemical reaction in which aluminum takes oxygen from iron oxide; the welded part is stronger than originally by reason of a collar of new metal around the fracture. For welding wire hoops, or one metal to another, electric-resistance welding, employing alternating current is used. Gas-welding, including oxy-acetylene welding, uses gases under pressure which are ignited at the tip of a blow-pipe.

*See Trans. Am. Soc. C. E., Vol. LXI, p. 332.

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The Boulevard System of San Francisco

By M. M. O'SHAUGHNESSY*

The importance of good roads and boulevards for the development of suburban districts cannot be over-estimated. Only within the last few years has proper attention been paid by San Francisco to this important subject. Before 1912 the roads leading into the city from the south were inadequate, rough, and unsightly. This defect has since been overcome by the construction of the Junipero Serra boulevard. Formerly this was a macadam roadway, 25 ft. wide, with an exceedingly high crown, sides dangerously depressed, and the whole roadbed more or less disintegrated. In reconstructing this main boulevard, which extends from Ingleside to the county line, a distance of 1.6 miles, the steep grades and sharp verticals were eliminated. A 25-ft. roadway in the centre was paved with a 6-in. concrete base, topped by a 1½-in. binder course and a 1-in. asphalt wearing surface. Concrete sides 6 in. thick confine the binder course and asphalt surface. There are macadam shoulders 5 ft. wide on either side of the asphalt roadway and these in turn are flanked by concrete gutters 5 ft. wide and 22 in. deep.

At the north the Junipero Serra boulevard connects with the eastern terminus of the Sloat boulevard. The latter has just been constructed and is an excellent example of the modern suburban road. When completed according to the original plans this boulevard will be 135 ft. wide. A central strip 35 ft. wide, which will be suitably parked, is reserved for the tracks of the United Railways. On either side of the tracks will be a 35-ft. roadway of the same type of construction as the Junipero Serra boulevard. The sides of the roadway will be protected by concrete curbs, inside of which will be a grass plot 5 ft. wide. Space beneath the grass plot is reserved for sewer, gas, and water-pipes. Artificial-stone sidewalks will adjoin the property lines. For the present only the southerly half of this roadway will be completed, the construction of the remainder being left until traffic increases materially.

To form a direct link between the centre of Golden Gate Park and Sloat boulevard, Nineteenth avenue has been converted from a macadam to an asphalt-paved thoroughfare, 2 miles long. This boulevard passes through a district which is being developed rapidly and the reconstruction of the roadway will be an improvement welcome to the district.

Another unit in the system of boulevards has been added by the reconstruction of Corbett road, which skirts the Twin Peaks ridge, and from which the scenic beauties of San Francisco, the Bay, and surrounding cities can be seen and admired. Above this road and at an average elevation of over 800 ft. above the sea, the 'figure-eight' boulevard encircles the two peaks. From this road a view may be obtained of the Pacific Ocean, the Santa Cruz mountains, the lower bay, the transbay cities, San Francisco, the Golden Gate, the Marin hills, and Mount Tamalpais. In no city in the world has a boulevard been constructed from which a greater variety of scenery can be viewed.

Recognizing the necessity of an additional entrance to San Francisco from the south-east, the Board of Public Works, acting on the advice of the city engineer, has procured a right-of-way for an extension of the San Bruno road, 80 ft. wide, so that the city will soon be provided with a wide, well-paved boulevard along the bay shore.

To develop the industrial district in the vicinity of the Hunter's Point dry-dock, a new road has just been projected by the city engineer. This will be 2¼ miles long and will extend from the intersection of Railroad and Evans avenues to Hunters Point dry-dock. It will have a uniform width of 80 ft. with 10-ft. sidewalks on either side. The roadway will be paved with asphalt. Within a few months construction will be begun at Hunters Point on one of the largest dry-docks in the country, costing approximately $2,000,000. The highway will furnish direct access to this plant and will also open many of the most valuable factory sites in San Francisco, fronting deep water.

Railroad avenue, the westerly terminus of the Hunter's Point highway, is being improved and will form an important link in the chain of boulevards recently undertaken. Starting at the intersection of Third street and the Islais Creek channel, this thoroughfare runs in a generally southwesterly direction until it intersects San Bruno avenue. The width between property lines is 100 ft., divided into a 70-ft. roadway and 15-ft. sidewalks. It is 2.2 miles long and at no point has a grade greater than 10%. For over half its length the grade is less than 4%. Proceedings are now under way by which the early completion of this boulevard will be assured.

Another road which has recently been partly completed is the Camino Del Mar, extending from Fort Miley, through Lincoln park, along the cliffs above Baker's beach, into the Presidio reservation. For the construction of this military road, $56,000 was donated by the Panama-Pacific International Exposition and approximately $30,000 in the purchase of realty by the city of San Francisco. The Federal Government has agreed to complete the road through the Presidio reservation, and it is hoped that this extension will shortly be made. From this boulevard a close view is obtainable of the entrance to San Francisco harbor, together with the inner bay.

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A great asset to San Francisco, which has been neglected for many years, is the ocean beach. Cities in the southern portion of the State have spent millions in developing their beaches in order to attract the tourist trade. Until last year San Francisco had done practically nothing toward capitalizing one of its greatest assets. The first unit of the ocean beach esplanade is now being constructed, however, and within a few years with the completion of this improvement the city will have added greatly to its attractiveness.

The beach esplanade, which will be over 200 ft. wide, will be protected on the west by a series of concrete steps surmounted by a reinforced concrete parapet-wall and the boulevard proper will be paved for a width of over 100 ft. The first unit is now being constructed at a cost of $50,000. An additional $100,000 will be expended during the coming year and each succeeding year a budget appropriation will be asked until the entire esplanade, fronting Golden Gate Park and extending southerly to form a link between the Camino Del Mar and Sloat boulevard, shall have been completed.

All of the roadways above mentioned have some suitable connecting link with the state highway system. California has expended $18,000,000 on road construction within the last five years. It is hoped that within the next few months $15,000,000 additional will be made available. If the proposed bond issue is approved, the benefit to the State and to San Francisco, its principal city, will be more than commensurate with the expenditure. California is the third state in the Union in the number of its automobiles. Most of these are passenger cars. An adequate road system that will provide an opportunity to residents of the cities to see the natural advantages of the State and impress upon visitors the wealth of its resources will earn its cost many times over.

PRODUCTION OF PETROLEUM FROM OIL-SHALE

The possibilities of the oil-shale industry are discussed by Arthur Selwyn-Brown in *The Engineering Magazine*. Oil-shale is found in many parts of the world including the United States, Canada, Newfoundland, Australia, Tasmania, South Africa, and Scotland. Deposits have been worked successfully for a number of years in Scotland, Tasmania, and New South Wales, the Scotch deposits being the most important. The chemical composition of oil-shales is similar to coal, except that the proportion of hydrogen to carbon is greater. There is also considerably more ash.

The shale is mined like coal. In some cases it occurs near the surface and can be quarried. In others, it has to be reached by shafts. It is distilled in large retorts. The gases given off from the shale are drawn into collecting chambers and passed through water-cooled pipe-condensers. The ammonia water and the crude oil pass into tanks, where the oil rises to the surface and may be drawn off. Some of the gas cannot be liquified in the condensers. This is cooled in an ice machine and compressed. In this way some gasoline is obtained. The rest of the gas is used for fuel. The crude oil is refined in the same way as oil from wells. The amount recovered varies from 30 to 100 gallons of oil and from 30 to 70 gallons of ammonium sulphate per ton. In Tasmania the spent shale is used as a fertilizer.

The commercial value of some of the Canadian shales has recently been tested. The cost of mining and retorting is $2 per ton. With oil at $4 per bbl. and ammonium sulphate at $0.03 per lb., the shale returns about $5 per ton, or a profit of $3 per ton. Pennsylvania oil is now worth $2.60 per bbl. at the well and there is every indication that it will go higher. At this figure it is probable that many of the shale beds could be mined at a profit.

Oil-shale is found in many parts of the United States, the principal deposits being in Colorado, Utah, California, and Oklahoma. They have never been mined, but it is probable that they are as rich as some of the Canadian and Scotch deposits.

PROPOSED HIGHWAY SURFACING AT ROSS, CALIFORNIA

The town of Ross in Marin county is situated about 20 miles north of San Francisco, with which it is connected by the ferry and trains operated by the Northwestern Pacific Railroad Co. The population is about 500, principally 'commuters' who are employed in San Francisco.

The existing road system comprises about eight and one-half miles of water-bound macadam roads. Seven miles of road was built under a bond issue in 1909 and 1910. The contractors were the E. B. and A. L. Stone Co. of San Francisco. The remaining mile and a half was constructed in 1912 for private persons. The construction was supervised by town officials and the roads were subsequently accepted by the Town. The contractors were Chadwick & Sykes of San Francisco. The roads are from 10 to 20 ft. wide and the total area of road surface is 80,000 sq. yd. The traffic is comparatively light.

The roads were originally constructed in a first-class manner and they have been carefully maintained, the average annual expense for sprinkling and other maintenance being $3500. It is largely to reduce this maintenance charge that surfacing the roads with a bituminous material has been proposed. At an election held April 10 a bond issue for $18,000 for this purpose received a large majority. The type of surfacing has not yet been definitely selected, but it will probably be a heavy asphaltic oil with screenings. The old macadam base is in excellent condition and will form a good foundation for any type of surfacing selected. It is estimated that there will be such a reduction in the annual maintenance charge that the surfacing will pay for itself in six years.

Bids will be asked as soon as the type of surfacing is decided, so that the work can be completed in the next few months. J. B. McCauley is town clerk and Laurence Thompson, 5842 Virmar avenue, Oakland, is engineer in charge of the work.

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Proposed Sewer System for Fresno, California

Plans have been prepared by city engineer B. E. Cronkhite for a comprehensive sanitary and storm-sewer system for the city of Fresno. An election has been called for May 3 to vote on a bond issue of $500,000 for construction of the system. Olmsted & Gillelen, of Los Angeles, have been appointed consulting engineers. Their report, which has recently been made public, indorses the proposed system, except for a few minor changes. Some doubt is expressed, on account of the quicksand formation likely to be encountered, of the possibility of completing the system with the proceeds of the bond issue, but it is shown that construction of certain parts of the storm-sewer system can be postponed for a few years if desired, without impairing the efficiency of the remainder of the system.

The report calls attention to the fact that the present sewer system is frequently overtaxed by the ordinary sewage-flow, causing the sewage to rise in the man-holes and the sewers themselves to discharge under pressure. It is certain that many of the pipe-joints are not water-tight under such conditions. This is particularly serious because the city water-supply is derived from wells, which although deep, might become contaminated. The provisions for the disposal of storm-water are also inadequate.

Following is the estimated cost of the proposed sanitary-sewer system according to the consulting engineers:

Pipe		
Vitrified pipe in trench	$7,100	
Vitrified pipe laying	766	
Laid	$7,866	$7,866
Brick sewers laid		$193,896
Excavation		57,674
Backfill		5,295
Wasting		1,340
Flooding		580
Man-holes		2,450
Sheeting and pumping		72,117
Resurfacing streets, asphalt		1,192
Resurfacing streets, oiled		1,200
Cleaning up		435
Superintendence		1,500
Liability insurance		12,000
Interest on capital, 6% on $100,000, 1 year		6,000
Tools, etc.		2,000
Sundries, 1%		4,300
Cost		$369,845
General allowance for contractor's profit, engineering, inspection and contingencies, 15%		55,477
Total		$425,322

This system will be adequate for the sewage of 146,000 people.

The storm-sewer system is designed to serve the congested district bounded by E. Calaveras, N. and Mono streets, and having an area of 330 acres. Dry creek lying on the west and an old drainage line on the east effectually limit the concentrated drainage area to this amount, with a slowly discharging subsidiary area of somewhat greater extent. Heavy storms are unusual but the run-off is slow on account of the light grades. The estimated cost of the storm-sewer system is as follows:

Vitrified pipe	$ 5,320
Brick and concrete sewers	119,430
Excavation	4,070
Backfilling, 12,240 yards, at 5c	612
Wasting, 1360 yards at 35c	480
Man-holes	1,000
Sheeting skeleton, 6477 at 13c., plus 12,364 at 10c	2,086
Repairing streets, asphalt, 20,650 sq. ft. at 20c	4,130
Cleaning up, 18,941 ft. at $0.015	282
Superintendence (charged to sanitary system)	
Liability insurance	4,000
Interest on capital	1,000
Tools, etc.	600
Sundries, 1%	1,430
Cost	$144,440
General allowance for contractor's profit, engineering contingencies, 15%	21,666
Total	$166,106
Cost of sanitary system	425,322
Total estimated cost of both systems	$591,428

It will be noted that this amount exceeds the proposed bond issue by $91,428. The report states that this estimate is liberal, and that it is possible, although not at all likely, that the system can be built for the amount of the bond issue. In order to reduce the cost of the proposed system it is suggested that the sanitary system be constructed as planned, which will liberate for other uses the present outfall sewer leading to the sewage farm and consisting of two 24-in. pipes. The collecting portion of the storm-sewer system could also be constructed and the two 24-in. pipes used as part of a storm-sewer outfall, which could then discharge through an open ditch into Dry creek. The construction of the proposed storm-sewer outfall could thus be postponed for several years, and the entire system completed for the amount of the bond issue.

Natural gas is produced in 22 States. The total output in 1914 was 591,866,733,000 cubic feet with a value of $94,115,524, or $0.159 per thousand cubic feet. California produced 17,828,928,000 cubic feet, valued at $2,910,784, or $0.1633 per thousand cubic feet. Of the total amount produced, about two-thirds was used by industrial, and one-third by domestic consumers. There were 2,073,099 domestic and 17,886 industrial consumers. Two-thirds of the amount used by industrial consumers was for manufacturing.

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The Chemistry of Portland Cement*

Portland cement clinker is the result of chemical combinations of the three oxides, lime, alumina, silica; but besides these three, which are the essential components, two others, namely, magnesia and ferric oxide, always occur to some extent in commercial cement. The average of a large number of chemical analyses of American-made portland cement is, according to Meade:

	%		%
CaO	62.0	Fe_2O_3	2.5
Al_2O_3	7.5	MgO	2.5
SiO_2	22.0	SO_3	1.5

From this it is evident that more than 90% of an average portland cement consists of the three oxides, CaO, Al_2O_3, SiO_2. One would expect, therefore, that its properties are due mainly to the presence of the above three components and that the relatively small admixture of the other oxides exerts at most a wholly secondary influence. Indeed, it has been shown that good portland cement can be made from the three pure oxides, lime, alumina, and silica, in the proper proportions.

Now, ordinary chemical methods enable us to ascertain the aggregate proportion of each oxide present, but they yield us no information as to the manner in which these oxides are combined with one another—in other words, as to the substances which actually are present in the clinker and are responsible for its characteristic properties. The determination of this question is important, for this reason; that, until we know what these substances actually are, we cannot hope to improve the method of making portland cement, or to improve the quality in any desired direction, except by cut-and-try methods. The determination of this question has been the object of a large number of investigations; but the experimental basis of most of this work has been altogether insufficient to decide the several questions at issue.

Cement clinker is a mixture of substances of similar properties, and is, moreover, exceedingly fine grained, as a consequence of which it is a matter of some difficulty to make quantitative determination of the constituents; but this difficulty can be surmounted by studying separately each of the presumable constituents of the clinker and determining definite values of certain properties which serve to characterize it and to distinguish it from other possible constituents. Accordingly the first problem is to isolate and determine all the possible compounds of lime, alumina, and silica which we may expect to find in portland cement clinker, to establish their relations at high temperatures and to ascertain their optical characteristics which constitute the most convenient and satisfactory criterion of the identity of the several substances.

These characteristic properties of the several solid substances, containing only CaO, Al_2O_3, SiO_2, which are likely to occur in portland cement have been determined at the Geophysical Laboratory of the Carnegie Institution of Washington in the course of a systematic investigation of all compounds formed when any mixture of these oxides is heated to a high temperature. In American-made portland cements the relative proportions of these oxides vary only between comparatively narrow limits: CaO, 60 to 64; Al_2O_3, 5 to 9; SiO_2, 19 to 25; in other words, in considering this special problem we have to deal with a restricted portion of the field of the whole system CaO-Al_2O_3-SiO_2.

The Ternary System CaO-Al_2O_3-SiO_2. In order to work out this system completely it proved necessary to investigate about 1000 different mixtures of these three oxides and to make about 7000 heat treatments and microscopical examinations of the resultant products. Each such mixture, which was always made up of especially pure materials, was alternately fused and ground to a fine powder, the fusions being made in a platinum crucible to avoid contamination, in order to obtain a thoroughly combined product. Each of these products was heated in an electric furnace, the temperature of which was carefully controlled and measured, until all changes had ceased, when it was quickly chilled; and the resultant material was subjected to a complete optical study. This procedure, which was carried out systematically, enables one to determine the crystalline phases present at temperatures ranging from that at which melting begins to that at which the charge is completely melted; and thus to ascertain the melting temperature and optical properties of all compounds of lime, alumina, silica which form when any mixture of these three oxides is heated.

The data thus obtained can be interpreted most readily if they are platted in three dimensions; the concentration (composition) of each mixture is represented by a point within an equilateral triangle† on the horizontal plane, the magnitude of the corresponding temperature by the distance above this plane. The series of surfaces thus described represents the melting temperatures of all products obtained when any mixture of the three oxides is heated progressively to higher and higher temperature. A photograph of such a model is reproduced in Fig. 1. As can be seen from the photograph, the model resembles a relief map of a mountainous region; each mountain peak is the melting point of a pure component or of a pure compound; the mountain slopes represent the melting temperatures of a component or compound in ternary mixtures; the points where the rivers

*Abstract of paper presented at the annual convention of the American Concrete Institute, Chicago, February 1916, by G. A. Rankin of the geophysical laboratory of the Carnegie Institute, Washington, D. C.

†In such a diagram, the pure components, CaO, Al_2O_3, SiO_2, are represented by the apices of the triangle, the binary systems, CaO-Al_2O_3, CaO-SiO_2, and Al_2O_3-SiO_2, by the sides of the triangle, and ternary mixtures by points within the triangle.

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in the valleys meet to form a lake are the lowest melting temperatures, known as eutectic points. This model, when interpreted with the aid of the principles underlying such equilibria, enables one to specify the order in which the several crystalline substances will form when any mixture composed entirely of lime, alumina, and silica is heated, and also to state what are the final products when the reactions have gone to completion.

Let us consider the crystalline substances which will form when a mixture composed only of these three oxides in the proportions such that they will produce a good portland cement, is heated. For this purpose a diagram such as Fig. 2 is useful. This diagram is a projection on the horizontal plane of that portion of the

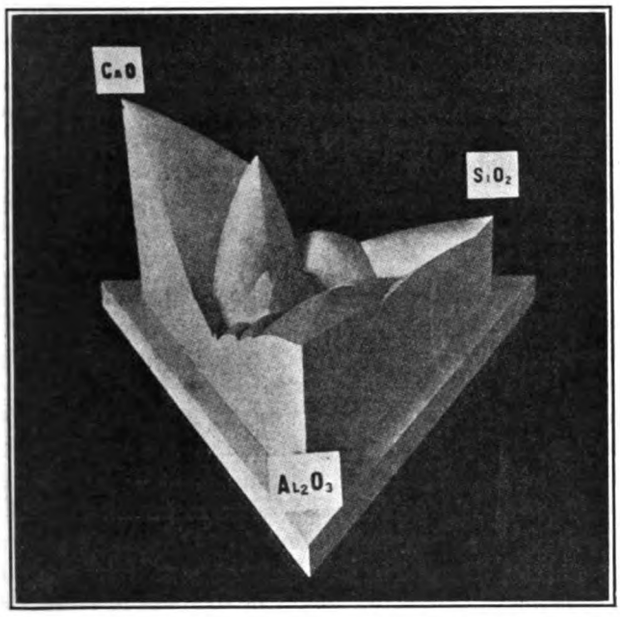

FIG. 1. SOLID MODEL OF CONCENTRATION-TEMPERATURE DIAGRAM OF THE TERNARY SYSTEM, CaO-Al_2O_3-SiO_2.

solid model necessary for our present purpose. The corresponding temperatures are here represented by isothermal lines, which are completely analogous to the contour lines on an ordinary map. In this diagram the group of dots represents mixtures of CaO, Al_2O_3, SiO_2 from which portland cement of good quality can be made.

This group of dots, it will be noted, are all included within the triangular area formed by lines connecting the compositions of the three compounds, tricalcium silicate, dicalcium silicate, and tricalcium aluminate. For that reason, if any mixture of CaO, Al_2O_3, and SiO_2, such as is represented by one of these dots, is heated so that all chemical reactions are completed, the final product obtained will be made up of the above three compounds.

The constituents of portland cement clinker made up only of the oxides CaO, Al_2O_3, SiO_2 are, therefore, the three compounds $3CaO.SiO_2$, $2CaO.SiO_2$, and $3CaO.Al_2O_3$. Each of these compounds has optical properties peculiar to itself which serve to distinguish it from the rest. The several characteristic optical and crystallographical properties were obtained by a study of each compound by itself. These values are constant for the individual compounds in all mixtures made up from pure CaO, Al_2O_3, and SiO_2; that is, the final products resulting when such mixtures are heated, are present as individuals of constant optical properties and not as solid solutions.

Microscopical examination of commercial portland cement clinker shows it to be made up largely (over 90%) of these three compounds, $2CaO.SiO_2$, $3CaO.SiO_2$, and $3CaO.Al_2O_3$. It would appear, therefore, that the value of portland cement as a cementing material when mixed with water is due largely to one or more of these compounds. Before taking up the cementing value of each of these compounds, however, let us consider their formation when portland cement is burned.

For this purpose let us follow the reactions which take place when a mixture whose composition is CaO (as $CaCO_3$) 68.4%, Al_2O_3 8%, SiO_2 23.6% (point *P*, Fig. 2),

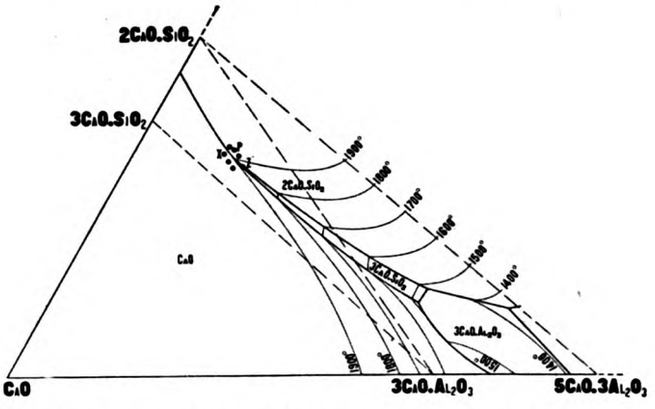

FIG. 2. PROJECTION OF A PORTION OF CONCENTRATION-TEMPERATURES OF TERNARY SYSTEM CaO-Al_2O_3-SiO_2 WITH ISOTHERMALS.

The dots represent the mixtures CaO, Al_2O_3, and SiO_2 from which portland cement of good quality can be made.

is slowly heated. This mixture, made up only of the pure oxides, lime, alumina, silica, when properly burned, will produce a good portland cement. When such a mixture is heated, the first change is the evolution of the CO_2; the lime then unites with the other components to form the compounds $5CaO.3Al_2O_3$ and $2CaO.SiO_2$ (both of which form readily) probably in the order named, since the former has a lower melting point than the latter; subsequently these two compounds unite in part with more lime, and the compounds $3CaO.SiO_2$ and $3CaO.Al_2O_3$ appear. This formation of the last two compounds, a process which goes on very slowly in mixtures of their own composition, is materially facilitated by the circumstance that in the ternary mixtures a portion of the charge has already melted and promotes reaction by acting as a flux or solvent. The temperature at which this flux first appears is 1335°C., the eutectic temperature for the three compounds $2CaO.SiO_2$, $5CaO.3Al_2O_3$, $3CaO.Al_2O_3$. As the temperature of burning gradually rises above 1335°, the relative amount of flux increases and the rate of formation of $3CaO.Al_2O_3$ and $3CaO.SiO_2$ increases correspondingly. At a tempera-

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ture somewhat above 1335° the compound $5CaO.3Al_2O_3$ will have completely melted in the flux and the formation of $3CaO.Al_2O_3$ is complete. The substances present as crystals at this stage are $3CaO.SiO_2$, $3CaO.Al_2O_3$, $2CaO.SiO_2$ and free CaO. Of these the $3CaO.SiO_2$ is rapidly increasing in amount, due to combination of $2CaO.SiO_2$ with CaO, while the amounts of solid $2CaO.SiO_2$, CaO, and $3CaO.Al_2O_3$ are all decreasing, the $2CaO.SiO_2$ partly by combination with CaO and partly by dissolving along with $3CaO.Al_2O_3$ in the flux. As the temperature is raised still further, the amount of flux liquid increases and the rate of combination of CaO with $2CaO.SiO_2$ to form $3CaO.SiO_2$ increases. But it is not necessary to raise the temperature until the charge is completely melted, as normal cement clinker is obtained at temperatures much below complete melting; in other words, the necessary reactions will go to completion below the temperature required for complete melting. The rapidity with which the reactions go to completion is governed by the temperature and by the amount of flux formed at that temperature. The requisite amount of flux in turn depends upon the fineness of the raw materials, since the finer these materials are ground the more readily the components will combine. For finely ground raw materials of the above composition, composed only of CaO, Al_2O_3, SiO_2, a temperature of about 1650°C. is required for burning. At this temperature the clinker would be about 30% melted and 70% solid crystalline material, a proportion of flux which would admit of the necessary reactions going to completion in a reasonable time. The charge will always crystallize completely on cooling; the percentage composition of the clinker thus obtained will be approximately $3CaO.SiO_2$, 45%; $2CaO.SiO_2$, 35%; and $3CaO.Al_2O_3$, 20%. The melting temperature of the flux necessary for the production of the clinker is materially lowered by the presence of small amounts of impurities; that the small amounts of Fe_2O_3,MgO, etc., in commercial cement actually have this effect is shown by the fact that the temperature required for burning is about 1425°C.

This description of the essential reactions which take place when cement made up only of CaO, Al_2O_3, SiO_2 is burned, applies equally well to commercial portland cement. In commercial cements, however, there is always present small amounts of Fe_2O_3, MgO, alkalies, etc. These minor components, which total less than 10%, have but little effect on the major constituents of the clinker. During the burning of cement clinker, however, these minor components play an important part, since their presence ensures the formation of a flux at a much lower temperature, and thereby materially promotes the combination of CaO with Al_2O_3 and SiO_2.

In order to afford a comparison of the chemical compositions, the temperature required for burning and the final products obtained for different types of portland cement, the necessary data have been collated in Table I. The examples given in this table are based on the average for a large number of analyses of each of three types of portland cement, namely, pure cement, made only of CaO, Al_2O_3, SiO_2; commercial white cement; and the more common gray variety of portland cement.

TABLE I.—COMPOSITIONS AND BURNING TEMPERATURES OF VARIOUS PORTLAND CEMENTS.[1]

Portland Cements	Actual Components. Percentage Composition of Clinker.	Relative to Content of CaO-Al_2O_3-SiO_2.	Burning Temperature, Deg. C.	Constituents of Resulting Cements.
Pure (P)	CaO..... 68.4 Al_2O_3..... 8.0 } 100.0 SiO_2..... 23.6	CaO... 68.4 Al_2O_3... 8.0 SiO_2... 23.6	1650	$2CaO.SiO_2$ $3CaO.SiO_2$ $3CaO.Al_2O_3$
White (A)	CaO..... 66.2 Al_2O_3..... 6.4 SiO_2..... 25.0 } 97.6 MgO, Fe_2O_3, Na_2O and K_2O..... 2.4	CaO... 67.9 Al_2O_3... 6.5 SiO_2... 25.6	1525	$2CaO.SiO_2$ $3CaO.SiO_2$ $3CaO.Al_2O_3$ } Small amount of CaO.
Gray (B)	CaO..... 63.2 Al_2O_3..... 7.7 SiO_2..... 22.4 } 93.3 MgO, Fe_2O_3, Na_2O, K_2O and SO_3..... 6.7	CaO... 66.7 Al_2O_3... 9.0 SiO_2... 24.3	1425	$2CaO.SiO_2$ $3CaO.SiO_2$ $3CaO.Al_2O_3$ } Small amounts of $5CaO.3Al_2O_3CaO$ and ferrites.

[1] The data given in this table are based largely on the work of this laboratory. The analyses of commercial clinkers are from publications from the Bureau of Standards and from "Portland Cement," by E. K. Meade. The temperatures of burning and the constituents given are based both on our work and that of the Bureau of Standards.

If the raw material for pure cement is perfectly burned at a temperature of 1650°, the clinker obtained will consist of the three compounds—orthosilicate of lime, tricalcic silicate, and tricalcic aluminate. The example of a pure cement, given in Table I, has the chemical composition 68.4% lime, 8.0% alumina, 23.6% silica. The raw material for white commercial cement, when burned at a temperature of 1525°, will produce a clinker which consists largely of the same three compounds found in pure clinker, except for a small amount of free lime. The average chemical composition of this type of cement as given in the table is 66.2% lime, 6.4% alumina, 25% silica, and 2.4% magnesia, iron oxide and alkali. The clinker obtained on burning the raw material for commercial gray cement at 1425° will consist largely of the same three compounds found in the other two types of clinker, except for small amounts of free lime, the compound $5CaO.3Al_2O_3$, and iron oxide as ferrites. The composition of this clinker is 63.2% lime, 7.7% alumina, 22.4% silica, and 6.7% MgO, Fe_2O_3, alkali, and SiO_2.

The similarity of these three types of cement clinkers is not surprising if we consider their chemical compositions. The content of lime, alumina, silica of each type is over 90%, while the composition relative only to these three oxides approaches a constant, the maximum difference being 2.5% in the case of alumina, since there is 6.5% in white cement and 9.0% in gray cement. We should expect, therefore, and it has been found experimentally to be true, that these three types of cement clinker are made up largely of the same constituents; these are, as we have shown, tricalcic silicate, dicalcium silicate, and tricalcic aluminate, all compounds of the three major components of cement.

Having shown that the components of portland cement are CaO, Al_2O_3,SiO_2 in certain rather definite proportions and that the constituent substances are definite compounds of these oxides, let us consider the proportion of these compounds in the clinker. For example, let us take the average gray cement whose chemical composition has been given in Table I. If the clinker for this cement has been perfectly burned, it will consist of about 36% $3CaO.SiO_2$, 33% $2CaO.SiO_2$, 21% $3CaO.Al_2O_3$, and 10% of the minor constituents.

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In the actual manufacture of portland cement, however, the clinker is not always perfectly burned, that is, the raw materials are not always ground fine enough, or heated to a sufficiently high temperature so that the chemical reactions are completed. The proportions of the constituents in commercial cement will then be somewhat different from those given. With our present knowledge of the nature of the chemical reactions, however, it is possible to state which of the constituents will not be completely formed. It will be remembered that, in the discussion of these chemical reactions, it was shown that $3CaO.SiO_2$ is the last constituent to form completely and this compound is formed by combination of CaO with the compound $2CaO.SiO_2$. It is evident, therefore, that when commercial clinker is not perfectly burned, there is less $3CaO.SiO_2$ and more $2CaO.SiO_2$ and CaO will be present as an individual constituent. In the example given there will be less than 36% $3CaO.SiO_2$, more than 33% $2CaO.SiO_2$ and there will be a certain percentage of free CaO. The exact percentages will of course depend upon how near to completion the reaction, $CaO + 2CaO.SiO_2 = 3CaO.SiO_2$ has been carried.

That the manufacture of good portland cement necessitates that this reaction be carried practically to completion is evident if we consider certain facts in regard to the influence of lime on the physical properties of portland cement. Practical experience has shown that cements containing much free lime are unsound and that concrete made from them will disintegrate in time. This is due to the expansion of free or uncombined lime when it reacts with water to form calcium hydrate. If, however, the lime in cements is all combined, they are sound and of good strength. The importance of the reaction $CaO + 2CaO.SiO_2 = 3CaO.SiO_2$, is therefore, apparent, since this reaction must go practically to completion in order that a sound cement may be produced. It has long been recognized that anything which will promote the combination of lime during burning will promote soundness in cement and that the greater the percentage of combined lime the greater the corresponding strength of the cement.

The average lime content of cement today is about 62.5%, which is largely combined as $3CaO.SiO_2$, $2CaO.SiO_2$, and $3CaO.Al_2O_3$. If the proportion of CaO were increased, it would tend to combine with the $2CaO.SiO_2$ to form more $3CaO.SiO_2$ and would so combine if the time of burning were long enough and the temperature sufficiently high. Since practical experience has shown that increased proportion of lime increases both the proportion of $3CaO.SiO_2$ and the strength of cements, it may be inferred that the strength of cements is largely due to the compound $3CaO.SiO_2$. If this is true, it is desirable that portland cement should contain as high a percentage of this compound as is possible. An average portland cement contains about 30 to 35% of this constituent. That portland cement contains such a small amount of $3CaO.SiO_2$ is due partly to the fact that this constituent is formed with great difficulty and also to the fact that about 40% is the maximum yield which could be obtained from raw materials having the same CaO, Al_2O_3, SiO_2 composition as are now used.

When portland cement is finely pulverized and mixed with water, a hard mass is formed by chemical action between the water and the constituents of the cement. While there is much to be learned as to the chemistry of the hardening of portland cement, sufficient data on the hydration of the individual major constituents have been obtained to enable us to account for the gradual hardening and increase in strength and to indicate the relative value of these constituents as cementing materials.

Let us now consider the hydration of the three major constituents, $3CaO.Al_2O_3$, $3CaO.SiO_2$, $2CaO.SiO_2$, in the order named. When pure $3CaO.Al_2O_3$ is mixed with water, an amorphous hydrated material is first formed. This material sets and hardens rapidly. The compound $3CaO.SiO_2$ when mixed with water, also sets and hardens rather rapidly. In the case of this compound, as in the case of $3CaO.Al_2O_3$, the setting and hardening is due to the formation of an amorphous hydrated material on the individual grains which are thus cemented together. The extent of the hydration or the percentage of amorphous material which each grain will yield depends upon the proportion of water used and the time. With a given proportion of water the amount of amorphous material formed from the compound $3CaO.Al_2O_3$ in a given time is much greater than for the compound $3CaO.SiO_2$, that is, the compound $3CaO.Al_2O_3$ reacts with water much more rapidly than the $3CaO.SiO_2$. The compound $2CaO.SiO_2$ reacts slowly with water and it is only after a long period of time that sufficient amorphous hydrated material is formed to cement together the grains of this compound and so form a hard mass.

The amorphous hydrated material formed by the action of water on the constituents of cement, does in time, no doubt, crystallize to some extent. From the data available it would appear that the crystals formed are calcium hydrate and some crystalline hydrate derived from $3CaO.Al_2O_3$. Apparently no crystalline hydrate of the calcium silicates is formed.

It will be seen that the setting and hardening of portland cement involves the formation of an amorphous hydrated material which subsequently partly crystallizes; that the initial set is probably due to the hydration of $3CaO.Al_2O_3$; that the hardness and cohesive strength at first are due to the cementing action of the amorphous material produced by the hydration of this aluminate and of the $3CaO.SiO_2$; and that the gradual increase in strength is due to further hydration of these two compounds together with the hydration of the $2CaO.SiO_2$.

Of the three compounds which thus take part in the setting and hardening of portland cement, the $3CaO.SiO_2$ appears the best cementing constitutent; that is, this compound is the only one of the three which when mixed with water will set and harden within a reasonable time to form a mass which in hardness and strength is comparable to portland cement. The compound $2CaO.SiO_2$ requires too long a time to set and harden, in order

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to be in itself a valuable cementing material. The compound $3CaO.Al_2O_3$, while it sets and hardens rapidly, is rather soluble in water and is not particularly durable or strong. From this, again, it follows that the compound tricalcium silicate is the essential constituent of portland cement, consequently the higher its proportion the better the cement.

In the discussion of the composition of portland cement we have shown that an average portland cement contains about 30 to 35% tricalcium silicate, a proportion which closely approaches the maximum possible yield if the components are in the proportions of an average portland cement. It has also been shown that an increase in the lime content of an average cement will increase the percentage of $3CaO.SiO_2$ if the conditions of burning are such that the reaction $CaO + 2CaO.SiO_2 = 3CaO.SiO_2$ goes to completion. This, however, necessitates finer grinding of the raw materials, as well as burning for a longer time and at an increased temperature, factors which materially affect the cost of production. Now the data discussed above were obtained by applying the results obtained by an investigation of the equilibrium relations found to exist in the system CaO-Al_2O_3-SiO_2, to the actual manufacture of portland cement; but this by no means implies that in presence of other components the conditions required for the production of an adequate amount of flux should not be more favorable and economical. In other words, the study of other systems may establish the economic possibility of producing a cement containing a high proportion of tricalcium silicate. For example, if some substance were substituted for the component Al_2O_3 in the system CaO-Al_2O_3-SiO_2, the study of the equilibrium relations found to exist in this new system would enable one to determine whether or not it would be economically possible to produce a cement containing a high proportion of $3CaO.SiO_2$ from raw materials of which the components are CaO, SiO_2, and this third substance. Thus if Fe_2O_3 were substituted for Al_2O_3, we could from the study of the system CaO-Fe_2O_3-SiO_2 ascertain the fineness of the raw material, and the time and temperature of burning, necessary to secure a clinker containing the highest proportion of $3CaO.SiO_2$ which could be economically produced from raw materials of which the major components are CaO, Fe_2O_3, SiO_2. This would require that one determine the nature of all compounds formed in mixtures of these three oxides which, when burned, contain $3CaO.SiO_2$, and that we establish the identity, melting temperature, and rate of formation, of $3CaO.SiO_2$ in such mixtures. Instead of substituting a single substance, it would undoubtedly be more desirable to substitute a number of different substances, since the presence of several produces a lower melting flux and thus makes possible the formation of $3CaO.SiO_2$ at a lower temperature. By proceeding in this way to determine systematically the various mixtures of substances, which, when burned, give high proportion of $3CaO.SiO_2$, it would not seem at all improbable that we may discover some mixture which could be economically manufactured and which would result in the production of a cement far superior to the portland cement now made.

In this discussion we have assumed that tricalcium silicate is the essential constitutent of portland cement. If subsequent investigation should show that other constituents possess superior cementing qualities, the nature of an investigation to determine the mixture which would produce economically the highest proportion of such a constituent, would be of the same general nature as that described for tricalcium silicate.

In conclusion, let us recapitulate the main points contained in this paper. The value of portland cement depends upon the fact that when finely powdered and mixed with water it forms a hard mass; and the strength and permanence of this mass depend upon the constituents of the cement. The major constituents are tricalcium silicate, dicalcium silicate, and tricalcium aluminate. Of these constituents, the compound tricalcium silicate is the one which hardens and develops the greatest strength within a reasonable time. This most important constituent, which is the one formed with the greatest difficulty, makes up only 30 to 35% of an average normal portland cement. It may be said, therefore, that the essential process for the manufacture of portland cement is the formation of this compound, and that any improvement in this process yielding an increased proportion of tricalcium silicate will increase the cementing value of portland cement. In order to determine the most economical process for producing tricalcium silicate in the highest proportion, it will be necessary to study the rate of formation of this compound in series of mixtures of various substances; this, in turn, necessitates the determination of the equilibrium relations of tricalcium silicate at high temperatures in such mixtures. Such a procedure will lead to the discovery of the optimum composition in various cases and for various purposes sooner than the empirical cut-and-try methods which hitherto have been tried.

CONCRETE MIXING AND PLACING

Twenty degrees was recommended as the least angle for concrete chutes at the National Conference on Concrete Road Building. The maximum amount of water recommended was 6 lb. per cu. ft. of loose material. It was brought out that there is a tendency among contractors to set the chute at too flat an angle in order to cover the widest area and then to use too much water in order to make the concrete flow freely. Pending further tests, the committee made the following recommendations regarding mixing concrete for road work:

1. The mixer drum should revolve at a speed not exceeding 16 revolutions per minute.
2. The minimum number of revolutions for each batch should be ten.
3. The minimum length of time for mixing each batch should be one minute.

Where concrete is mixed for less than one minute it has been found that the water is not worked through the mass.

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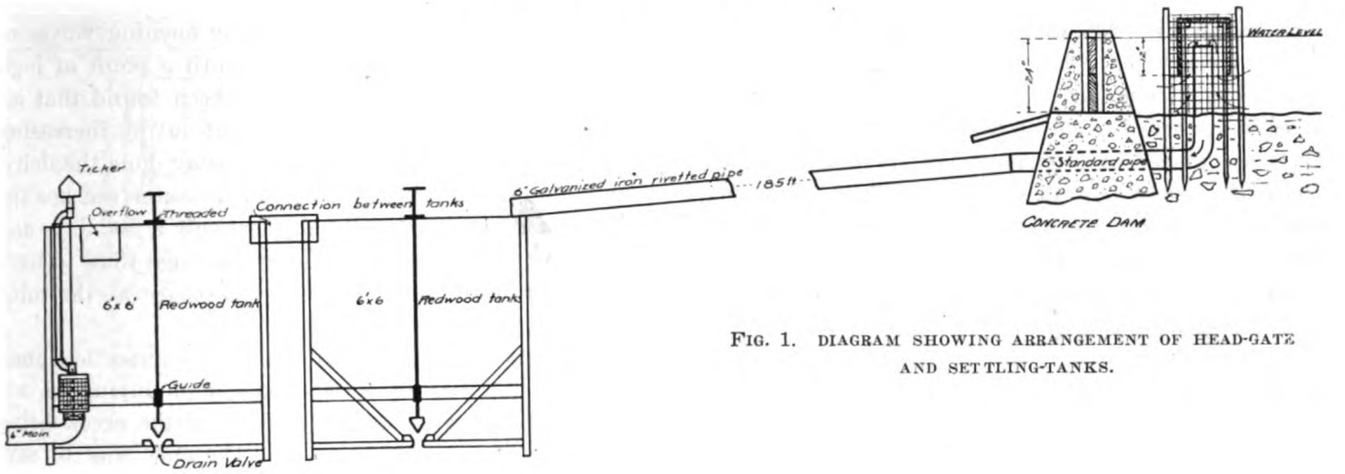

FIG. 1. DIAGRAM SHOWING ARRANGEMENT OF HEAD-GATE AND SETTLING-TANKS.

The Nevada Wonder Pipe-Line

Automatic Devices for Checking Interruptions to Service

By J. A. BURGESS

A geologist, in writing of the mineral resources of a large area in California, mentioned water as the most important mineral. It is not usual to think of water in this way, but the geologist's remark was strictly true, and would apply with equal force to the entire world. The truth that he stated is most appreciated in localities where water is scarce; and in the oases of the arid regions, where industry depends on a scanty water-supply, it is not uncommon to hear recognition of the fact openly expressed.

An ample supply of water is particularly necessary for mining and milling plants and in some localities it has to be brought for a great distance at big expense. Any interruption of the supply causes a corresponding cessation of milling operations, and therefore every possible precaution should be taken to insure against such a contingency. This paper describes the means used for this purpose at the Nevada Wonder mine, at Wonder, in Churchill county, Nevada.

The pipe-line was laid in the latter part of 1910. It conveys water by gravity-flow from Horse creek to the mine, a distance of 10 miles. It is in the form of a broad letter U. From the point of intake the course of the line leads downward through a valley until a point 2135 ft. below the intake is reached; thence it rises to the storage-tanks at the mine, where the elevation is only 465 ft. lower than the intake.

The line is built of standard, guaranteed full weight, steel pipe, with screwed joints. The same kind of couplings are used as on extra heavy pipe. The flanges and valves of the original equipment were of the type known as 'hydraulic,' but on all subsequent repair-work 'ammonia' flanges were used. The pipe was dipped in asphaltum before shipment by the manufacturer. The diameter at the intake is 6 in., reducing to 5 in. at 500 ft., and to 4 in. at 1000 ft. It has a covering of from 10 to 18 in. of soil. Air-valves and drain-valves are placed

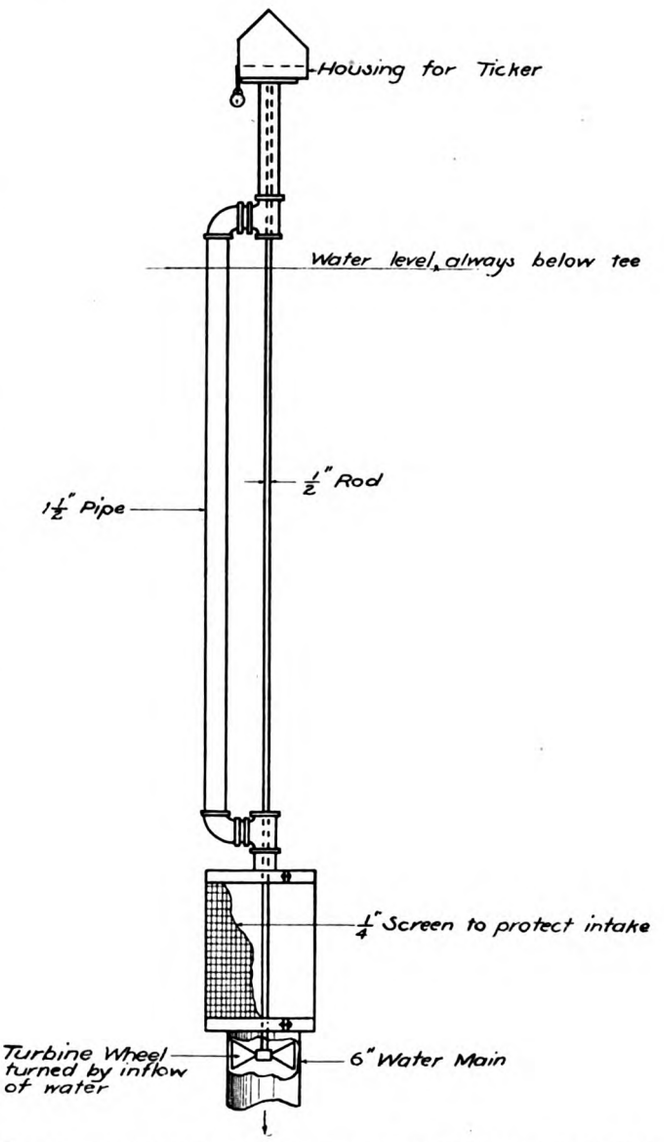

FIG. 3. TELEPHONE FLOW-INDICATOR FOR INTAKE OF WATER-MAIN.

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at all peaks and sags where air or sand might collect. These are also of use when it becomes necessary to drain the pipe-line. They are one-inch hydraulic-compression valves, and there are 46 of them on the line. Shut-off valves are placed at four important points. The pressure at the lowest part of the line is 920 lb. per square inch, and an automatic valve, set to release at 1000 lb. pressure, is situated at this point to protect the pipe from sudden increases of pressure due to water-hammer from the too sudden closing of a valve.

The calculated capacity of the line is 185,000 gallons per 24 hours, and this checks fairly closely with the actual delivery. The rate of flow in the pipe is 2.57 ft. per second.

The chief sources of trouble are clogging of the intake-screens by leaves, breakage of the pipe at joints by longitudinal contraction in cold weather, pitting by corrosion, stoppage of the flow in the creek by freezing, and freezing of water in the pipe. Uncovering of the line is brought about by cloud-bursts, by cattle using the mound for a trail, and by badgers digging off the covering, evidently mistaking the sound of flowing water for the noise of insects or small burrowing animals.

The obvious remedy for clogging of the intake by leaves is to have the screens cleaned frequently. The interval between cleanings can be kept within reasonable limits by having the screen-area sufficiently large. Contraction breaks at joints, though never frequent, gave more trouble during the first three winters than since then. They took the form of cross breaks at the threaded ends. The adjustment of irregular strains and the elimination of weak spots by breakage and repair put an end to the trouble. There are no expansion-joints in the line; the numerous bends would make them superfluous. Pitting of the pipe has caused no trouble except in the valley, where the pipe was penetrated several times in the fourth year. These breaks occurred within half a mile of each other, and were doubtless due to an excess of alkali in the soil. The pitting was from the outside. A protective coating applied to the pipe at the time it was laid would have prevented this deterioration, but the coating applied by the manufacturer before shipment was partly rubbed off during transportation.

Excessively cold weather forms the principal source of danger. With the thermometer not lower than 10° or 15° F. at night the line is safe. With temperatures between 10° and 5° above zero, the line must be watched closely, and when the night temperatures are below 5° it is in danger. The lowest temperature recorded in five years was −11°. During the present winter freezing began in the pipe after three nights with the temperature at 4° below zero. At this low temperature the rate of flow in the line is not sufficient to prevent the formation of ice. A good covering of snow on the ground acts as a blanket and greatly reduces the danger of freezing. The ends of the line, being at the higher altitudes, are in the greatest danger of freezing; and when a decrease in the flow is observed during a cold snap, the means used to prevent a total closure of the line is to increase the rate of flow at the intake end by opening valves in succession from the delivery end, until a point of high pressure has been reached. It has been found that ice formed in the pipe can be rapidly cut out by increasing the flow in this way. While this is being done the delivery end of the line is drained, and no water reaches the mine; but the cold spells usually last only a few days and it is better to endure a temporary shortage than to have the line frozen. There is storage capacity at the mine sufficient to run the mill for three days.

During normal winters Horse creek carries less than twice the quantity of water taken, and during an excessively cold night there is danger of the creek being completely stopped by freezing. The only way to save the line in a case of this kind would be to drain it entirely.

During the unusually cold winter of 1912-'13 this line, like many others in the West, experienced disaster, and the experience of that winter suggested steps to prevent a repetition of the trouble. Considerations of expense and the necessity for maintaining a continuous water-supply prevented the deepening of the trench, but additional covering was mounded over the pipe. A telephone line was built from the head-gate to the mine, several permanent telephone stations were established, and two portable sets were provided. A flow-indicator was devised and placed at the intake, arranged so that the rate of flow could be approximately read at any telephone-receiver. A device was attached to the mine end of the line to give instant warning of a stoppage of the flow. Arrangements were made to keep a watchman at the head-gate during dangerously cold weather, and a typewritten program covering every possible contingency was furnished to him, as well as to a rancher three miles below the intake, and to several employees at the mine. This program specified exactly the duties of each man in case of a threatened freeze-up, and provided for the complete draining of the line, if necessary, within an hour after receiving warning. All telephone-poles and valve-boxes were marked with consecutive numbers.

The arrangement of the head-gate and the mechanical protective devices are as follows: Fig. 1 shows the arrangement of the head-gate and the settling-tanks. The dam backs up water to a depth of two feet. Removable boards, set horizontally in grooves, afford a means of sluicing out gravel accumulated during freshets. The entire bottom of the canyon is formed of loose rock-debris and soil, and the grade is so steep that a storage-dam would be impracticable; and in addition to this the danger of cloud-bursts forms an objection to the erection of expensive headworks. For these reasons no improvements beyond those strictly necessary were made. The intake at the dam is arranged to give a constant water-level, and to take the water from a depth of 12 inches below the surface. By these means a considerable depth of ice on the dam does not interfere with the flow into the pipe, as long as there is running water in the stream. As an additional protection, the dam is boarded over in winter. Ample area of screen, ¼-inch mesh, is shown sur-

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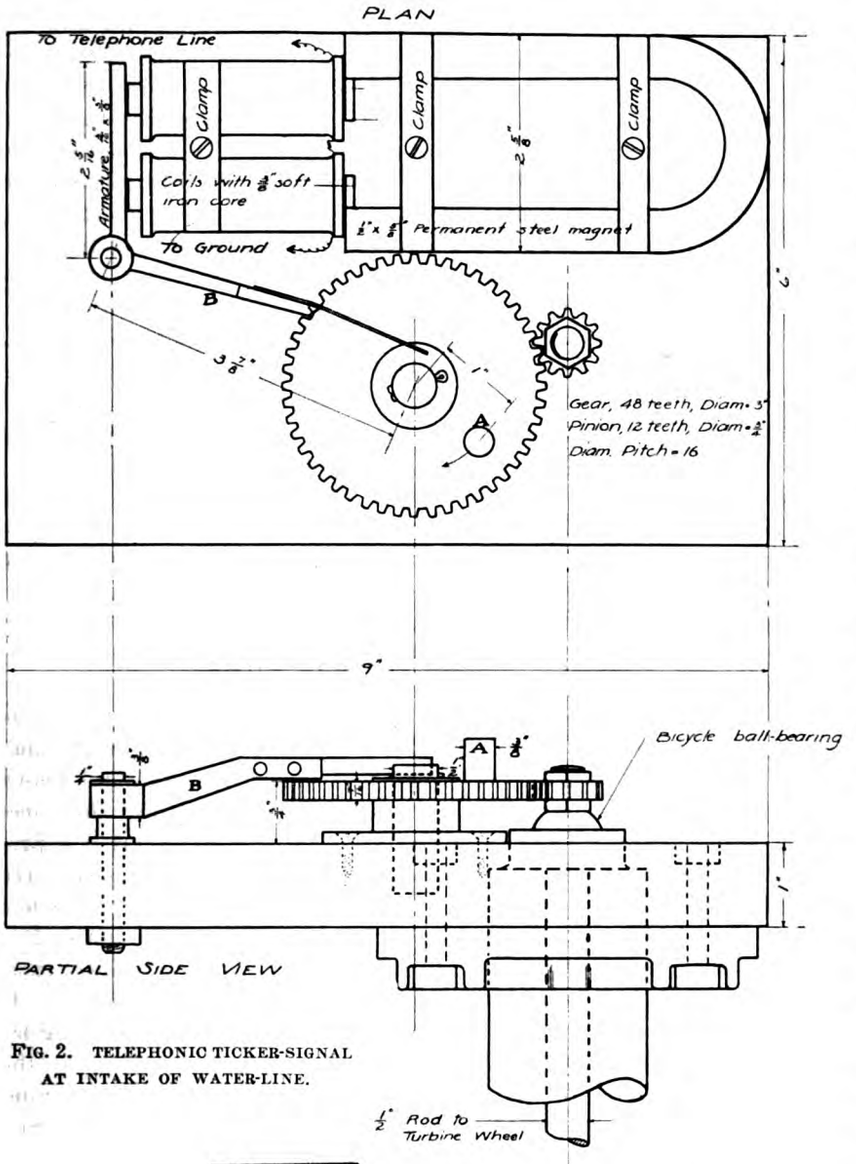

FIG. 2. TELEPHONIC TICKER-SIGNAL AT INTAKE OF WATER-LINE.

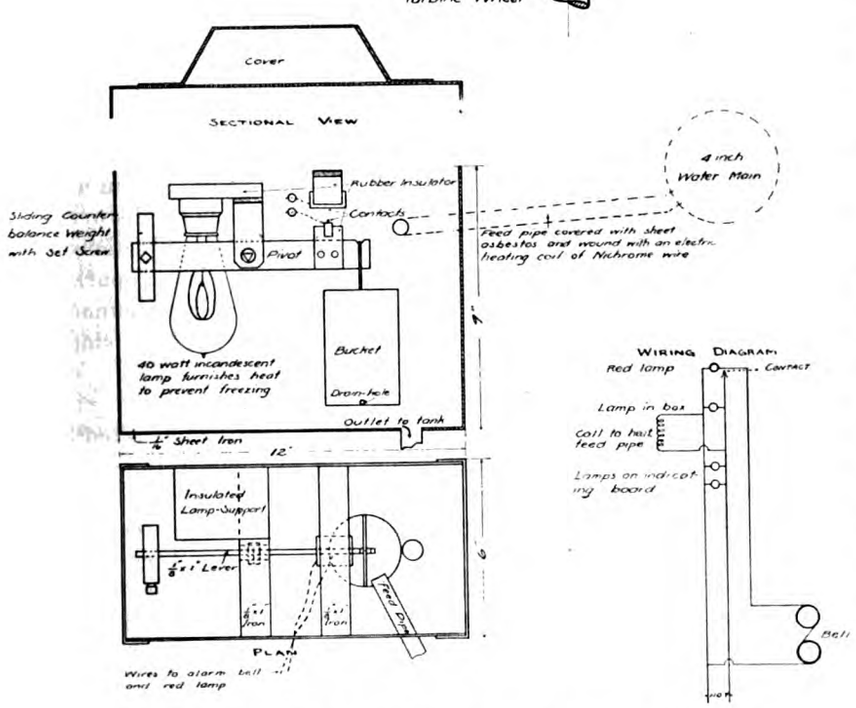

FIG. 4. SIGNAL ON WATER TANKS, NEVADA WONDER MINING CO.

rounding the intake. Two small tanks are provided for the purpose of trapping sand. The first has a conical bottom, and both are furnished with discharge plugs operated from above by threaded rods. Both tanks are covered. They are placed at the side of the canyon where only an unusually heavy cloud-burst would damage them. Delivery from the dam to the tanks was originally made through a square wooden flume, but when this became leaky, galvanized sheet-iron pipe was laid inside of it.

In Fig. 2 and 3, are shown the details of the telephonic flow-indicator, commonly called a 'ticker.' It consists essentially of a turbine-wheel just inside of the intake end of the water-main, by means of which the armature of a permanent magnet is periodically removed from its poles. The interruption of the magnetic flux induces an electrical impulse in a coil about the magnet. The coil is grounded at one end and attached to the telephone wire at the other, and each movement of the armature produces a clicking sound in the telephone receivers that is easily heard but is not sufficiently loud to interfere with conversation. The telephone line is connected with all the company telephones, so that the indicator may be heard in all offices and residences. The operation of the ticker is readily understood from the drawing. At each revolution the pin *A* displaces the arm *B*, which is integral with the armature. The bicycle ball-bearing forms a thrust-bearing that supports the entire weight of the rod and turbine-wheel, so that the lower bearing of the turbine-rod is simply a loose guide-bearing, and requires no lubrication. The only attention required by the ball-bearing for the past two years has been a few drops of oil occasionally. Its housing is kept locked. The support is made of pipe, but the drive-rod passes through only a part of its length. We ascertained that occasionally accumulations of air in the pipe-line bubbled back to the tank, and when a straight support was used, the gurgling air-bubbles entered the support and drove water upward through the bearing into the ticker. In cold weather this water froze and stopped the apparatus.

Fig. 4 shows the warning apparatus attached to the delivery end of the pipe-

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line at the storage-tanks. A small tin can with several punctures in the bottom is attached by a bail to a beam. The beam is supported by a pivoted axis like the beam of a pulp-balance. The bucket when empty is over-balanced by a weight at the opposite end of the beam, so that the bucket end rises and an electrical contact is made. When the bucket is full of water it over-balances the weighted end and the contact is broken. A bleeder pipe, ½-in. diam., taps the horizontal part of the water-main where it discharges into the tank, and leads to the bucket. When water is being delivered into the tank a small stream flows continuously into the bucket of the alarm apparatus, and the electrical contact is held open. If the water ceases to flow in the main pipe, none is delivered to the bucket and its contents leak out through the holes in its bottom. This permits the bucket end of the beam to rise, and the electrical contact thus established simultaneously lights a red incandescent lamp on the tank, and operates a loud-ringing polarized bell at a place in the mill where a mill-hand is always within hearing distance. To prevent freezing of the apparatus and of the small pipe leading to it, an incandescent lamp is kept lighted within the box, and a heating-coil is placed around the bleeder-pipe. Lights are maintained on the boards on which the water-level of the tanks is indicated, so that they may be read at night. The wiring diagram is shown in Fig. 4. A 110-volt alternating current is used. It will be observed that the bleeder-pipe does not tap the water-main exactly at the lower side. This is so that the alarm will be given when there is a serious decrease in the flow, and before it stops entirely. The apparatus is inspected and the bucket cleaned daily during cold weather. Small solid particles or scales from the pipe sometimes gather in the bucket and stop up the holes unless this is done.

The ticker is the pulse by which the performance of the water system may be watched. Under normal operating conditions it sounds 24 times per minute. If it works faster than this, it is a certain indication of either a break in the line or an open drain-valve. If the ticker sounds less than 24 times per minute, the reduction is due to decreased flow and may be caused by several circumstances. Except in freezing weather, it is apt to be caused either by air or sand in the pipe, or by leaves partly clogging the screens at the intake. In very cold weather it may be caused by a shortage of water in the creek or by freezing in the pipe. Only an inspection of the intake will distinguish between these possibilities, and it is partly for this reason that a watchman is kept at the head-gate during cold weather. At such times the temperature of the water in the stream is at 32°, and even a short stoppage of the flow in the pipe would result in a freeze-up. It is necessary, therefore, to obtain prompt information of conditions at the head-gate when there is any decrease of flow in the line. The alarm apparatus at the storage-tanks gives notice of any serious decrease of delivery, whatever the cause. By means of these two devices, and with a reasonable amount of attention, the danger of a freeze-up has been practically eliminated.

The ticker is also of great help when water is being forced through the line after draining it in cold weather. By using a portable telephone, the working crew can observe any stoppage that might be caused by the freezing of undrained pockets of water. In such a case the first valve back of the obstruction should be opened to maintain the flow until the obstruction is removed. Great care is taken under these circumstances to maintain a continuous flow.

The ticker is susceptible of use for a variety of purposes. By it the speed of operation of any piece of machinery can be indicated through a telephone line.

A few notes on methods of repair may be of interest. In thawing the line after the freeze-up of 1913, it was found that running a stream of water through the ditch, where this could be done, thawed the pipe just as effectively as a fire. When frozen only in isolated spots, the trouble can be easily detected between two valves. To determine the exact spot, the pipe is dug up at intervals, and tapped by boring holes 15/32 in. diam. When the obstruction is removed the hole is threaded and closed with a ½-in. plug. The flanges used in the construction of the line were faced flat, and where these were subjected to high pressure, trouble was experienced through the blowing out of gaskets. In all repair-work, heavy ammonia flanges are used. In these fittings the faces are made in matched parts. On one face there is a projection ½ in. wide and ¼ in. high, and on the opposite face there is a groove of corresponding dimensions, in which is placed a fiber gasket $\frac{1}{16}$ in. thick. Heavy fittings of this kind are peculiarly suited to repair-work, since their construction allows of using a heavy strain on the bolts to overcome a slight error in cutting inserted lengths. It is now planned to avoid the trouble caused by the freezing of small pockets of water after partly draining the line, by blowing out the residual water with air from the air-compressor at the mine.

A radio-direction finder has been developed by the Bureau of Standards. The finder indicates the source of the messages at the same time that they are being received. While it is sensitive to radiations in a given direction, it is less affected by atmospheric disturbances and interfering radiations from other directions than an ordinary receiving instrument. The apparatus is portable, requires neither ground nor antennae, and can be carried in a light vehicle or even by a single observer.

Topographic surveys were made by the United States Geological Survey during the year ended June 30, 1915, of 20,508 square miles not previously surveyed, making the total area surveyed in the United States 1,218,290 square miles, or 40.2% of the entire country. In addition, 3048 square miles of re-survey was completed, making the total area of surveys during the year 23,556 square miles. The cost per square mile of the work ranged from $4 on the Elizabeth Lake, California, quadrangle to $227 on the Sabine River project in Texas. The average cost was $22.

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Construction and Maintenance of Gravel Roads

Roads on gravelly soils are discussed in the *Reclamation Record,* by Andrew P. Anderson, engineer for the U. S. Office of Public Roads and Rural Engineering. Such soils offer the most favorable conditions for the construction and maintenance of such roads as will meet the ordinary requirements of farm traffic. This does not mean that all gravel is suitable for road-building, or that any method of construction will produce satisfactory results.

On rare occasions the supply of suitable material is distributed so that a certain amount of grading and draining is all that is necessary to secure a good road. More often, the character of the soil varies from place to place, and the material suited for a wearing surface is found in limited deposits. Frequently, a road may be constructed with the inferior gravel found on the ground and finished with selected gravel. Where the soil contains too much clay, sand or gravel containing very little clay may be added. Clay or gumbo may be added to a gravel deficient in binding qualities. Where traffic is heavy during the dry season, and especially where a large part of it is motor-driven, the cost of maintaining a gravel road will be excessive, and it should be hard-surfaced.

A good road-building gravel must have certain definite qualities. First of all, it must bind or consolidate well on the road. This binding or cementing property is due mainly to three factors: First, the proper proportion of clay or other binder. This is particularly important in a climate subject to long dry spells. In general there should be from 15 to 20% of clay. Moreover, the clay should be of such a character as to bake and become hard when dry. A clay that crumbles readily when dry is of small value as a binder. The second desirable quality in the gravel is the shape of the individual particles; the more angular they are the better will be the mechanical bond. The third consideration is the proportion of the different sizes, which should be arranged so as to give the minimum number of voids.

Clay may be added to a gravel to improve the binding quality, improper proportions may be corrected by mixing gravels in the proper ratio from different sources, and excess sand or too large pebbles may be removed by screening. Sometimes a gravel carrying a large amount of boulders can be run through a crusher and made to yield a material but little, if any, inferior to the best broken stone.

The preliminary grading depends upon the topography and local conditions necessary to secure adequate drainage. In general the principal source of danger to a gravel road in an arid region is not during winter or during rainy seasons, but during the dry weather. The side ditches should be shallow and the crown low unless it is reasonably certain that there will be an exceptional amount of seepage water from excessive irrigation of the land adjoining the road. As long as a properly constructed gravel road has a certain amount of moisture it will not ravel or go to pieces. The aim therefore must be to conserve and retain this moisture and keep the road surface from drying out completely. When local conditions are favorable, shade trees may be planted along the roadside. In still other places it may be possible to make provisions for flooding the road a few times during the dry season. Where irrigation water is plentiful, this possibility of flooding the road at necessary intervals should be well considered before construction is begun.

The necessary depth of gravel to be placed on the road depends on the character of the traffic, the nature and condition of the subgrade or foundation, and the character of the gravel used for the surfacing. In general practice the thickness of the consolidated gravel in a well-constructed road varies from six to ten inches. Owing to the practical impossibility of consolidating this amount of gravel at one time, the gravel is usually placed in two courses.

The particular details of the construction will vary with local conditions and the machinery available, the amount of work to be undertaken, and many other factors, that can be determined only by a close study of all the conditions involved. Good gravel roads have been built without the use of any special machinery, but this entails considerable hardship for a time on the passing traffic. Loose gravel is almost as great an obstacle to traffic as loose sand. Whenever a road roller is not available, the work should be done either immediately preceding or else during the early part of the rainy season, so that the gravel may be consolidated thoroughly before the dry season begins. Unless a road roller and water for sprinkling are available the construction of a gravel road is not advisable after the beginning of the dry season.

The construction of a gravel road should never be undertaken unless definite provisions for maintenance are assured. A newly constructed gravel road needs special attention for at least a year before the surface becomes thoroughly consolidated and bonded. After each rain and, if necessary, at other times when the gravel is moist enough to pack, the split-log drag or other similar device should be used to fill the ruts and maintain the crown. The drag should, however, never be used on a dry road. When the road is too dry to drag, a hand garden-rake will be found very useful to fill ruts and incipient chuck-holes. A slight covering of straw or similar fibrous material may be used to good advantage to prevent or to check raveling during dry weather.

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The Discharge From Vertical Pipes

By C. E. GRUNSKY *

While assistant state engineer of California from 1881 to 1888 I had to examine many artesian wells and found it necessary early in this experience to devise a formula that would enable a quick estimate of discharge, using as basic elements the diameter of the well and the height to which the outpouring water rose above the top of the well-casing.

The formula which proved satisfactory was made public in a paper read before the Technical Society of the Pacific Coast on October 3, 1884,† and has not, so far as I know, been superseded by anything better. Although the formula was based on but few experiments, it is fairly dependable when applied to wells that are four inches or more in diameter, and may be equally so for smaller wells, but on this point I have no information.

Let D = discharge in cu. ft. per second
d = inside diameter of the casing in feet
h_o = height in feet to which water rises in the centre over the top of the casing.

Then as originally written:

$$D = \frac{10 d \sqrt{h_o^3}}{\sqrt{1 + 2.525 \left(\frac{h_o}{d}\right)^2}} \qquad (1)$$

$$\text{or} \quad D = 10 d^2 \sqrt{\frac{h_o}{d^2 + 2.525 h_o^2}} \qquad (2)$$

$$\text{or} \quad D = 10 d^2 \sqrt{\frac{h_o}{\left(\frac{d}{h_o}\right)^2 + 2.525}} \qquad (3)$$

When h_o is small in comparison with d, the denominator in (1) approaches unity, and, with sufficient accuracy for the special case in which the rise of the water above the top of the casing is less than one-tenth of the diameter of the casing, the formula may be written

$$D = 10 d \sqrt{h_o^3} \qquad (4)$$

and the similarity of the formula to that for a sharp-edged weir will be recognized.

If in this formula the length of the weir crest $3.1416d$ be introduced it will be seen that

$$D = (3.18d)(3.1416) \sqrt{h_o^3}$$

whereas the well-known Francis weir formula would make, for the special case under consideration,

$$D = (3.33d)(3.1416) \sqrt{h_o^3}$$

The formulæ (1), (2), (3), and (4) are applicable to the flow from vertical pipes, of wrought iron or other thin material such as ordinarily used for well-casing.

When h_o is small, overfalling water may adhere to the outside surface of the casing. In this event before h_o is measured the water film must be broken and air admitted under the overfalling sheet of water. To measure h_o a thin scale, with knife edge, may be used. The measurement is made at two points at the opposite end of a diameter with the scale held radially so as to offer least obstruction. Care must be taken to sight for both readings in the same horizontal plane. The top of the water dome will generally be undulating and the observation should continue long enough to get its mean elevation and not the extreme momentary rise of the water at the centre. The value of d is the mean of two inside diameters at right angles to each other.

The well-borer's practice, when he has finished his work, is to wet a saw-blade, cover the same with fine sand or dust and place the same back down, on edge across the top of the casing. The extreme height of the sand washed off is his estimate of the rise of the water above the top of the casing. This method of determining h_o would give too large a value and is not therefore advisable when the formula is to be applied.

Example: What is the flow in gallons per 24 hours of an 8-in. artesian well in which the water is found to rise 3 in. (0.25 ft.) above the top of the casing?

Let it be supposed that the average of the two diameters which were measured is exactly 8 in., then:

$\frac{d}{h_o} = 2.667$ and $\left(\frac{d}{h_o}\right)^2 = 7.11$

$$D = 10 \times 0.667 \times 0.667 \sqrt{\frac{0.25}{7.11 + 2.525}}$$

$D = 0.715$ cu. ft. per second $= 460{,}000$ gal. per 24 hr.

Costs of operation of light automobiles are summarized in a bulletin recently issued by the U. S. Office of Public Roads and Rural Engineering. Three low-priced cars were used in supervising maintenance of the Washington-Atlanta highway and were driven an average of thirty to forty miles throughout the year. All the quantities given below are weighted averages for all three cars. The average cost of gasoline was $0.181 per gallon. Mileage per gallon was 17.59. Mileage per lb. of grease was 423. Mileage per quart of lubricating oil was 66.43. The cost per mile for gasoline was $0.0104; for grease, $0.0004; for lubricating oil, $0.0023; for tire casings, $0.0065; for other tire cost, $0.0018; for storage charges, $0.0052; for miscellaneous expense including one overhauling for each car, $0.0147; a total of $0.0413. These are, of course, operating costs only, and do not include interest and depreciation.

*Consulting engineer, Mechanics Institute Bdg., San Francisco.

†'The Flow of Artesian Wells,' by C. E. Grunsky, Transactions of the Technical Society of the Pacific Coast, 1884.

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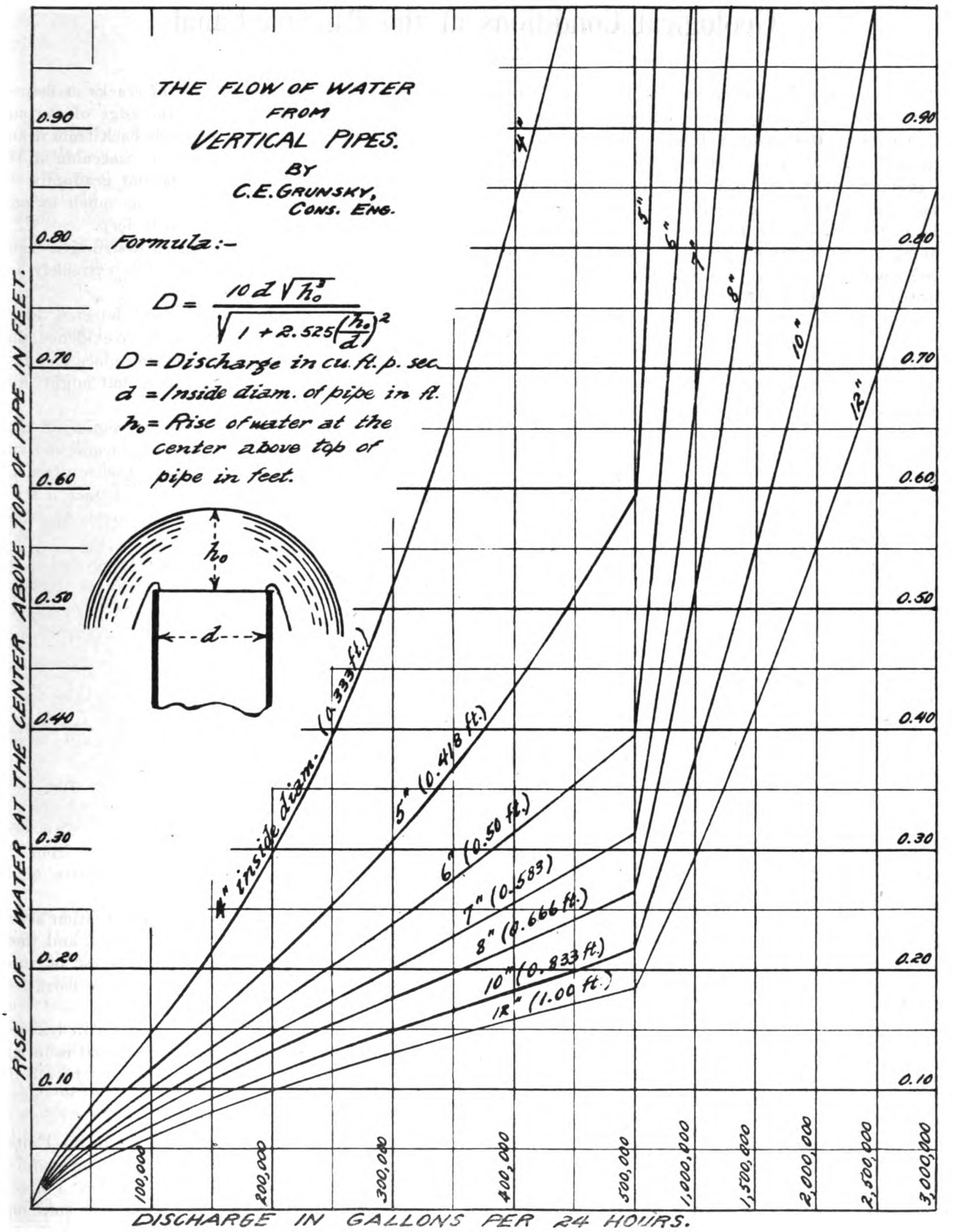

CHART FOR COMPUTING DISCHARGE.

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Geological Conditions at the Panama Canal

Some engineering problems of the Panama Canal in their relation to geology and topography are discussed by Donald F. McDonald in Bulletin 86 of the United States Bureau of Mines. Mr. McDonald was detailed as geologist to the Panama Canal, while it was under construction, and is now with the Bureau of Mines. The paper aims to discuss, from the viewpoint of the mining geologist, the bearing of topographic and geologic conditions on certain problems that arose in the construction of the Canal.

In all, there is a clear record of four oscillations in the region of the Canal and the beginning of another elevation. The average rate of uplift for, say, the last 1000 years has been less than 3 ft. in 100 years. It is believed that the sinking of the ocean bottom outside the relatively shallow depths of the isthmian shore-waters has been the chief cause of the earthquake periods that have, so far as the records go, visited the isthmus every 30 to 35 years and that each of these seismic disturbances has resulted in some increased elevation of the land mass. From the various oscillations of the land above and below sea-level, one would expect that the rocks constituting the isthmian land mass would have become broken and dislocated in these upward and downward movements, and this is the case. Great fracture planes cut the rock and trend mostly north-east and south-west, or approximately parallel with the axis of the land mass, with some minor fractures leading in other directions. Along these fracture planes differential movements, some of which measure hundreds of feet, have taken place. The frictional drag of these movements has crushed and broken the softer rocks for several feet on each side of the plane of motion.

This faulting has had an important bearing on engineering, because the faulted zones, especially where the rocks are extensively crushed and broken, have tended to promote slides. Culebra Cut is a vast ditch that passes through many varieties of rock in the nine miles of its length. Some of these are weak and unstable, and where the slopes of the cut were steep and from 100 to 300 ft. high, the weaker rocks were crushed down to flatter slopes. The flatness depended on the material involved, but, whatever the material, whenever the slope got flat enough the sliding stopped. The slides have made necessary the excavation of about 30,000,000 cu. yd. more than was included in the first estimates for Culebra Cut, but they have not in the past and will not in the future endanger the ultimate success of the Canal. The largest and most important slides developed from structural breaks and deformations. Fortunately, they occurred only near Culebra in a section of the cut not much over a mile long. These deformations first manifested themselves by the appearance of either one or of a set of cracks or fissures parallel or somewhat oblique to the edge of the cut, and from a few to hundreds of yards back from it and from each other. Some of them were traceable on the surface for several hundred yards and gradually developed into perpendicular crevices as much as one-third of a yard wide and many yards deep.

Though it is not impossible that a destructive earthquake might visit the Canal, still it is extremely improbable for the following reasons:

1. The large number of tremors detected every month by the recording instruments is evidence that slow adjustments are constantly taking place and thus that no great accumulations of stress that might later culminate in a big shock are probable.

2. The absence from the Isthmus region of high mountains and of geologically recent volcanic activity is evidence in favor of the probable absence of earthquakes, especially as such high mountains are a striking geologic feature of the whole Central American earthquake belt.

3. The presence of numerous small faults and of the faulted conditions of such volcanic cores as Gold hill and Contractors hill is evidence that adjustment here has progressed well on toward normal conditions of equilibrium.

4. The tensile strength of the majority of the rocks within the Canal Zone is rather low, and they would shear with comparative ease, thus preventing any relatively great accumulation of stress that might result in a comparatively intense shock. However, experience teaches that where earthquakes happen, the buildings suffering the maximum destructive effects are those built on loose and friable material. This consideration might therefore subtract a little from the saving benefits of the yielding and preventive qualities of the Canal Zone rocks.

5. Over 300 years of earthquake observation shows only two shocks of considerable magnitude, and there is every reason to believe that the severest of these would not have seriously damaged even the most delicate parts of the Canal.

That many small and harmless shocks will traverse the Canal Zone is certain but that the Canal is in any real danger from earthquakes is contrary to all the evidence.

The per capita consumption of cement in the United States in 1914 was 0.79 bbl. The largest consumption was in California, 1.70 bbl.; the smallest was in Mississippi and South Carolina, each 0.11 bbl. The consumption in Oregon was 0.94 bbl., in Washington, 1.11 bbl., in Arizona, 1.20 bbl., in Nevada, 0.57 bbl., and in Idaho, 1.19 barrels.

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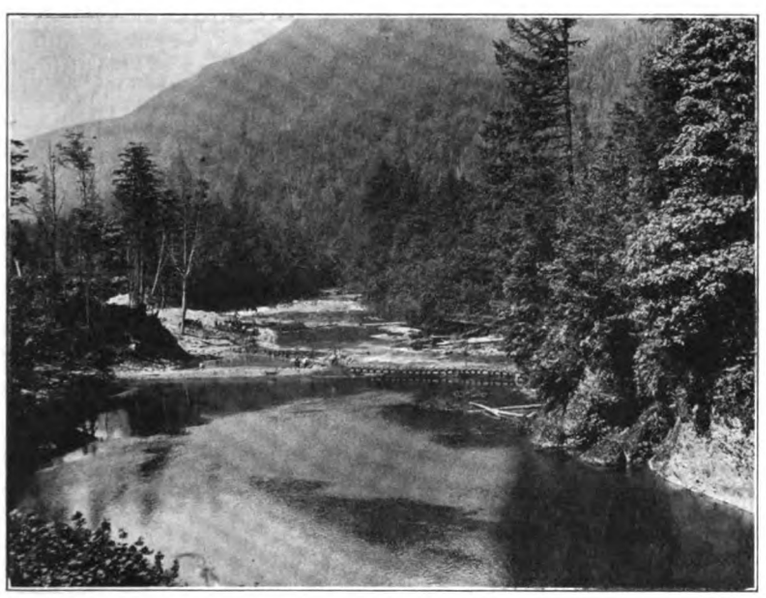
Foundation Types for Piers

By CHARLES EVAN FOWLER*

The selection of the type of foundation to use for any particular location must depend to a great degree upon the judgment of the designing engineer. However, by an analysis of the various methods, we can discover certain limits for the various types and reduce the chance for mistakes to a minimum.

The simplest method consists of merely an earth-bank coffer-dam. This may be used for obtaining a foundation at a depth of a few feet. Where the material consists of sand, gravel, and clay that has to be excavated and that has enough stability, combined with imperviousness to water, to make it possible to form a bank around the excavation that is stable and fairly watertight, it may be pumped out for a depth of from six to ten feet, and the foundation laid bare. When a depth below scour has been reached, the foundation may be placed. If the material is too soft, piling must be driven on which to place the concrete base or else to carry a grillage of timber below low water, on which to lay stone.



EARTH BANK COFFER-DAM WITH LOG-CRIB.

A grillage of timber on piles may often be employed in shallow water where there is no danger of scour, without the use of a coffer-dam if the timber is all below low water and if rip-rap is to be placed around the piles to ensure stability.

Such a grillage foundation may be constructed in depths of water up about 15 ft. by building the grillage as the bottom of a box with sides that may be removed after the foundation is completed, and sinking this box on the piles. The piles should be previously cut off to an exact level. To attempt to drive the piles with a follower to an exact level is not advisable.

Sheet-pile coffer-dams without puddle, formed of a single wall of some approved form of sheet piles of proper thickness, in general should not be used beyond a depth of 15 ft. Where they can be driven into reasonably impervious material or such material banked up around the outside, they can be used for depths up to 30 ft. Unless the material at the bottom is reasonably watertight or a seal of concrete is used, it is usually impossible to pump out such a coffer-dam.

Double-walled sheet-pile or crib coffer-dams with a puddle of clay containing some gravel, have been used up to a depth of 40 ft., but the limit of economy of such a coffer-dam is usually reached at 20 ft. Where they are to be used beyond 20 ft. it is often necessary to use three rows of sheet piling, thus forming a double puddle-chamber, although it is not necessary for the outside puddle-chamber to extend the full height.

Single-walled cribs are often used for rock bottom and for sinking in earth, but a concrete seal should be used before pumping them out, or else practically all the concrete must be placed under water. They have been used for considerable depths, but it is generally a mistake to employ them beyond 30 ft. Even then they must be well constructed, braced and calked, or else there will be difficulty in sinking them and in pumping them out even after a concrete seal has been deposited and allowed to set.

Where timber is cheap double-walled cribs may be used for depths up to 170 ft., but they must be carefully designed and constructed, and the concrete shell placed to sink them. There can be little reason for pumping any portion of them in order to place concrete, provided it is placed with the proper kind of a *tremie* judiciously used. However, it might be found desirable to place the top 20 or 30 ft. of concrete in the dry in cases where the pier has to carry a large load, which must be evenly distributed over the entire area of the pier. Such cribs are sunk by dredging through the wells left in the shaft. Dredged piers may be made of metal construction, such as were used for the Hawkesbury bridge in Australia to a depth of 160 feet.

Tubes of metal, braced together to form piers have been used more often in the past than they will be in

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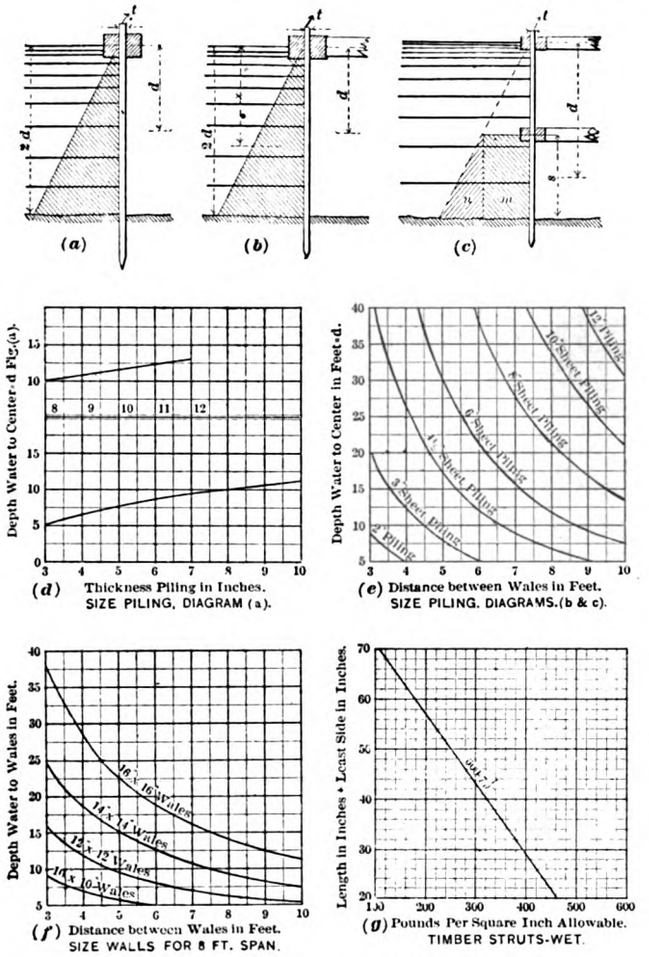
the future. They should be sunk by dredging out the interior with an orange-peel bucket. If piles must be driven first, the material should be removed with an hydraulic elevator, as the shells are sunk around the piles. The tubes may be constructed of such type and strength that they may be pumped out after a concrete seal is placed, or else so that they can be sunk by the pneumatic or compressed-air method.

The pneumatic caisson may be used up to a maximum depth of 110 ft., corresponding to an air pressure of

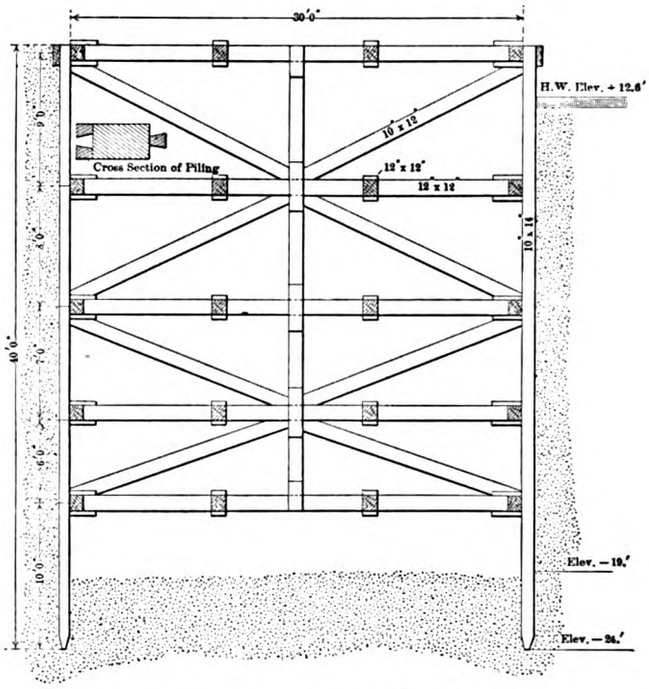


SECTIONS AND CHARTS FOR ORDINARY COFFER-DAMS.

about 50 lb. per sq. in. The caissons may be constructed of metal or else of timber, where such construction is cheaper and where the teredo will not destroy the timber or where the pier has been designed with this destruction in view. The reasons for using a pneumatic caisson are security in sinking, no matter what material or obstructions are encountered, and certainty as to the material on which the pier is finally landed.

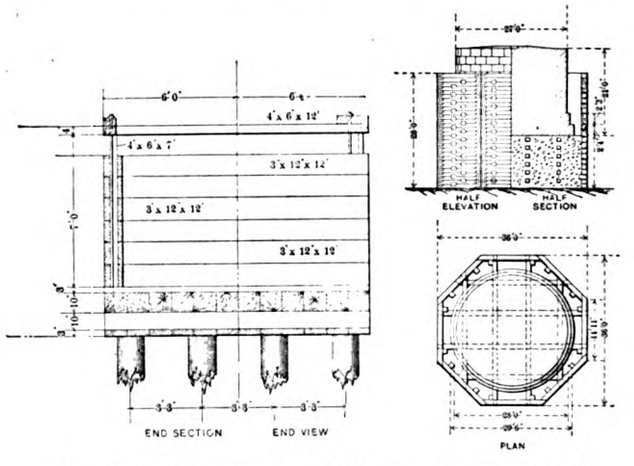
Piers may be sunk to a depth of about 110 ft. by the pneumatic process and from this point to the required depth by discontinuing the air pressure and using open dredging. This usually gets the pier below the depth where there is danger of trouble from logs or boulders before the pneumatic method is discontinued and brings the dredging into clean material.

The difficulty usually encountered in keeping a crib or caisson level and vertical, when it is being sunk through water before striking the bottom is taken care of in a single-walled crib by the weight of the cutting edge, and in a double-walled crib or caisson, both by the cutting edge and by depositing the concrete filling in



SHEET PILES THROUGH SOFT EARTH.

proper quantities. Where the caisson must be sunk through a great depth of water, such as the 130-ft. depth for one group of four piers in my design for the proposed San Francisco-Oakland bridge, some special means must be employed for handling the caissons, keeping them trimmed, and landing them. This has led



CRIB RESTING ON ROCK, ALSO GRILLAGE WITH REMOVABLE COFFER-DAM.

to the designing of a special form and type, which I have named the 'Ballmatic' pier. This design includes the use of specially designed ballast-tanks and of compressed air in handling, sinking and landing them.

With this review of the principal methods, we are

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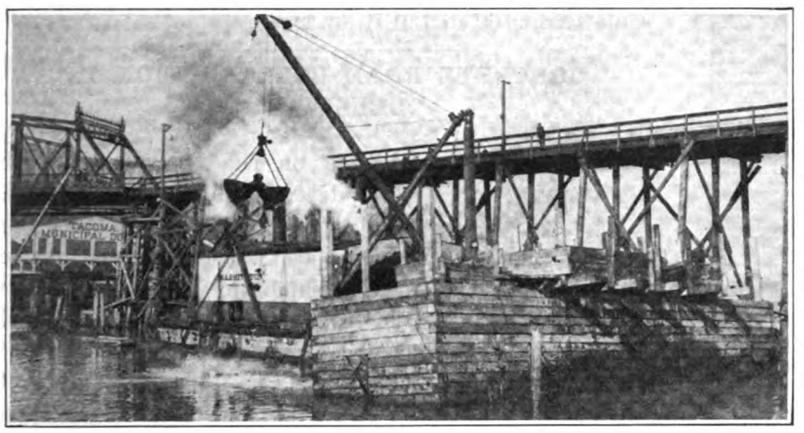
prepared to discuss the basis upon which a selection of type may be made for any given case, understanding of course, that there may be two or more that can be used for any particular location. In such an event the decision must be made on the basis of cost and certainty of result. The cost of foundations is variable for the same method in different places, even though the work may be designed and supervised by the same engineer. For many years the only tabulation of costs by various



SINKING SINGLE-WALL CRIB WITH CLAM-SHELL BUCKET.

methods that was available was given in 'Foundations' by Jules Gaudard. This is, however, compiled from widely separated cases and conditions, and is of slight value.

The accompanying table gives costs per cubic yard by the various methods, in different classes of material and at varying depths. These costs are based on like conditions and when applied to any given case will give results that may be relied upon for comparative purposes and for preliminary estimates. The table may show one method to be the cheapest in a particular case and yet the engineer may decide that it is wiser to use a method that, while costing more, will be better from an engineering standpoint and be more sure in its results.

APPROXIMATE COST OF FOUNDATIONS PER CUBIC YARD*

(For preliminary estimates only)

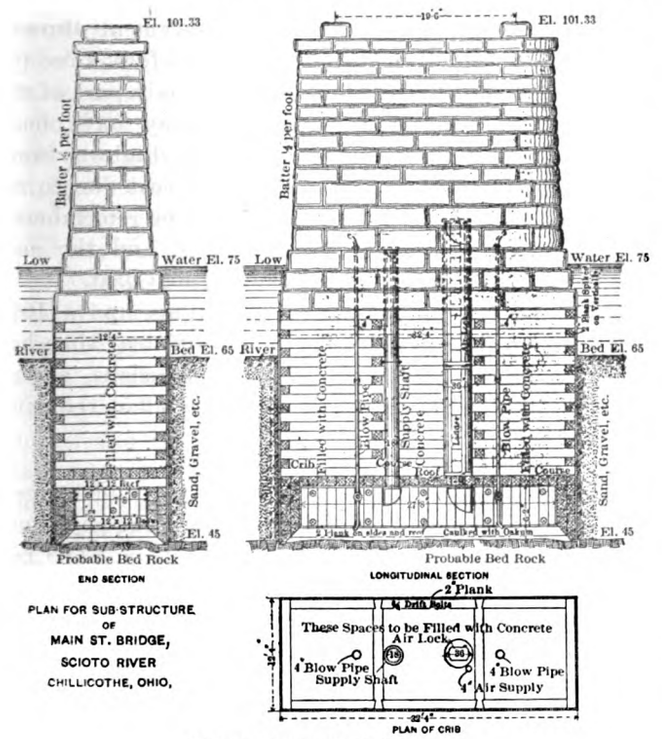
Depth, ft.	Soft ground.	Medium.	Hard.
CONCRETE BASE, 6 FT. THICK ON PILES			
18	$3.50	$4.50	$5.50
28	3.00	4.00	5.00
38	2.50	3.50	4.00
CAISSONS OR WELLS SUNK BY DREDGING, NO PILES			
30	9.00	11.50	15.00
40	12.00	15.50	22.00
50	15.00	18.50	....
COFFER-DAM PUMPED TO FOUNDATION-BED, NO PILES			
20	9.50	10.50	12.50
25	11.50	14.00	17.50
35	13.50	18.00	....
CONCRETE UNDER WATER, PLANK DRIVEN FOR FORMS AND DREDGED OUT, NO PILES			
20	7.50	9.50	....
25	9.50	13.50	....
35	12.00	18.00	....
PNEUMATIC CAISSONS WITH CONCRETE FILLING			
40	12.00	18.00	25.00
60	18.00	24.00	30.00
80	24.00	29.00	35.00
100	30.00	35.00	40.00

*'Sub-Aqueous Foundations,' Charles Evan Fowler, John Wiley & Son, New York.

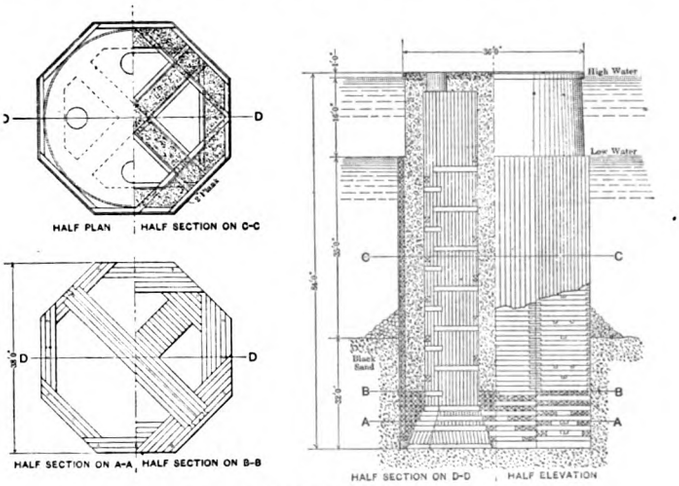
The above approximate figures are based on the usual medium-sized piers. Very large piers will cost somewhat less per cubic yard, while small piers will cost considerably more.

The arbitrary limits as to the various methods may be summed up as follows:

Earth-bank coffer-dams should not be used beyond a depth of eight or ten feet and never in a current swift enough to erode the material, unless combined with a log crib to prevent erosion. Such a log crib will in-



SMALL PNEUMATIC CAISSON.



DREDGED DOUBLE-WALL CRIB.

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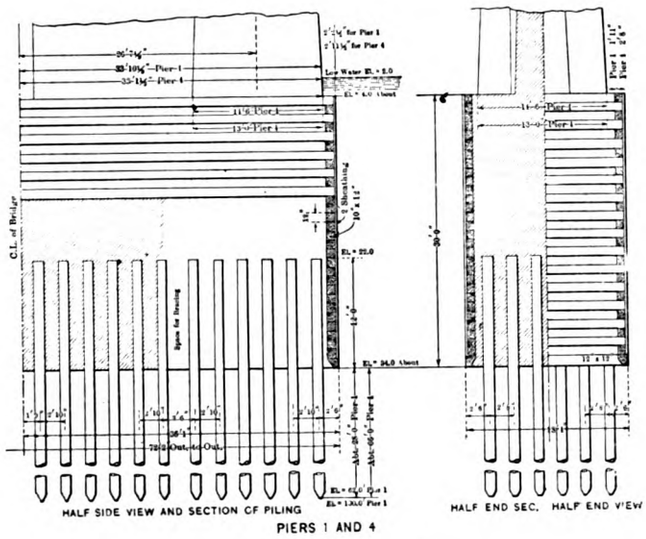
crease the possible range of depth up to 12 to 15 feet.

Sheet-pile coffer-dams should not be used without puddle beyond about 15 ft. in depth, nor with puddle beyond 20 ft. With earth penetration for a considerable portion of the depth they may be used up to 30 feet.

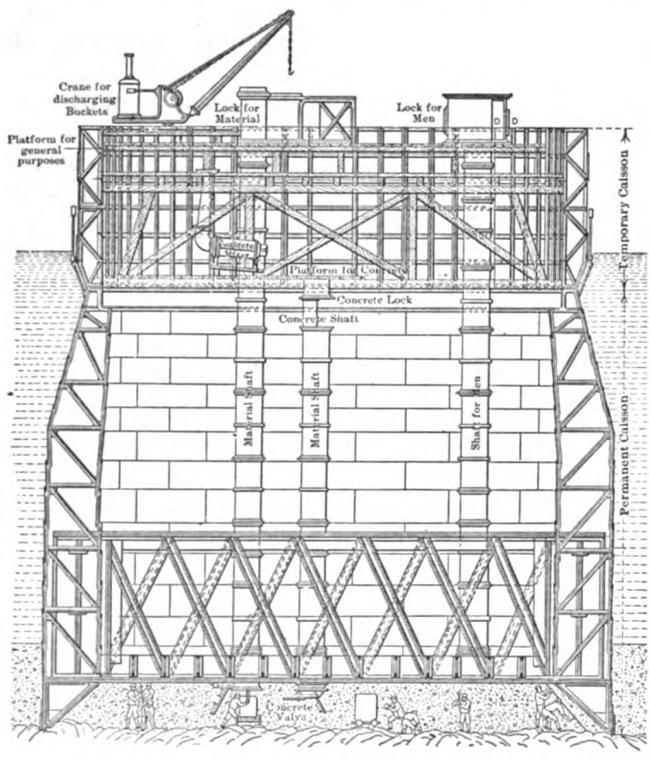
Crib coffer-dams should not be used beyond a depth



DREDGED SINGLE-WALL CRIB.

of 30 ft. and then not unless a concrete seal is to be used.

Where the material is favorable for dredging, dredged caissons may be used from a depth of 20 ft. up to any distance to which it is necessary to go in order to get hard bottom, or to reach a depth where the friction on the sides of the caisson added to the bearing-power of the base, will enable it to carry the load.



METAL CAISSON OF FORTH BRIDGE.

Where the depth is less than 30 ft., pneumatic caissons may be used in rare cases, but their proper field is for depths from 30 to 110 ft. where obstructions to sinking are likely to be encountered, and where it is necessary to reach such depths for proper bearing or to obtain sufficient frictional support on the sides.

'Ballmatic' caissons may be used for the foundations of piers where the depth of water overlying the bottom ranges from 60 to 130 ft. or more.

CONCRETE ROAD CONSTRUCTION IN DELAWARE

Methods of construction on the DuPont concrete highway in Delaware are described by Charles Upham, chief engineer for the highway, in the *Engineering Record*. Expansion joints are placed only when the concrete mixer stops for as much as 15 minutes. The pavement is 14 ft. wide, 7 in. thick at the centre, and 5 in. on the sides, and placed on a flat subgrade.

Part of the pavement has been laid with and part without reinforcement. One division of the highway is reinforced for the entire width with No. 29 American Steel & Wire Co. mesh reinforcement. The weight of reinforcement per sq. yd. is 2.52 lb. Wherever the slab was less than 178 ft. long, no cracks have appeared. Another division is reinforced for the entire width with No. 25 Kahn expanded metal. The weight of reinforcement per sq. yd. was 2.25 lb. Where the slab was less than 164 ft. long, no cracks have appeared.

Other divisions were reinforced with the Kahn metal for a distance of 3 ft. and also of 4 ft. on each side of the centre line. More cracks appeared in these pavements than those that were reinforced for the entire width. Divisions of unreinforced pavement showed more cracks than divisions that were reinforced for the entire width, but not so many as where only part of the pavement is reinforced. This last may have been partly because the reinforced parts of the highway were laid the most recently. The increased cost due to reinforcement is 9c. per sq. yd. It should be remembered that this work is near the steel-mills, and the cost would be somewhat higher on the Pacific Coast.

Hydrated lime in varying proportions up to 10% was used on part of the highway. Sufficient time has not elapsed to draw any definite conclusions, except that the addition of the lime is beneficial in reducing the number of cracks.

Costs of highway surveys in Idaho are summarized in the first biennial report of the State Highway Commission, recently issued. They ranged from $4.65 per mile for 89 miles of preliminary line through an open, diversified country between Crystal and Boise to $43.20 per mile for 70 miles of preliminary and located line in mountainous country from New Meadows to White Bird. The average cost for the entire State for 1446 miles of line was $15.41 per mile.

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Reinforced Concrete in Sewer Construction*

By W. W. HORNER †

About 1900, reinforced concrete commenced to be used in sewer construction. During the next five years, many examples of concrete sewers are found, although with a few exceptions the reinforcement consisted of wire mesh or expanded metal and there was an evident tendency on the part of the majority of engineers to use rather heavy sections similar to the plain masonry types. A few examples are also found of extremely radical designs involving very light sections heavily reinforced. These two extremes suggest the difference between the sewer engineer adapting his designs to reinforced work and the concrete expert breaking into the sewer field. During the past ten years, all of these ideas have been through the melting pot, and we are beginning to find certain standard types of reinforced concrete sewers used generally. These include the horseshoe type varying in proportions from semi-circular to about equal height and width, and the elliptical, usually constructed as a five-centred arch. The circular sewer is difficult to construct in what is know as 'monolithic' work, that is, if built in place, but the circular reinforced concrete pipe developed along other lines has become standard construction for sizes up to about 8 ft. It is unit work and may be considered as a factory product. For that reason a much more satisfactory concrete can be secured than is generally obtained in monolithic work.

Cross Sections. In many cases, the shape of the sewer will be controlled by local conditions. In wet ground the invert must be kept as high as possible and a broad, shallow section results. For such cases the semi-circular shape is the most economical, and in fact is about the limit of distortion in that direction, as computations show that little further decrease in height can be obtained by adopting a wider, flat segmental-arch. For such extremes where the semi-circular is not satisfactory, it is possible to design a box section, and if necessary, a multiple box, though this latter should always be compared with a similar multiplication of arches before being adopted. Where the sewer is deep, and in particular, if in rock, there is usually economy in making the heights of the section greater than the widths, and if in deep rock cut, it is possible to use plain concrete sides and a flat arch resting on the rock. Under average conditions the most economical section is undoubtedly one approaching nearly to the circle, that is, having width and height about equal, but on account of the difficulty of securing satisfactory construction with a semi-circular invert, a segmental invert (usually a 45 to 60° segment) has been common.

For loads due entirely to earth pressure and for sewers through fully developed territory where the loading can be determined definitely, arch sections of the semi-elliptical type can be employed to advantage, as the concrete can be used in direct compression for the normal load and reinforcement placed to allow for unusual conditions. But where the loads cannot be predicted with reasonable accuracy or where extreme loads of opposite character must be provided for, there will be little difference between the semi-elliptical and semi-circular sections and there is undoubtedly a prejudice in favor of the latter.

The great advantage of the reinforced arch for use in sewer construction lies in the economy in material. In large sizes, 8 ft. or over, the reinforced concrete sewer requires only from 60 to 80% as much masonry as the gravity type. Also where the amount is sufficient to warrant an efficient plant, the unit cost of the concrete should be somewhat less than that of good brick masonry. In addition to the saving in masonry, there is usually a proportionate difference in excavation. In deep work this may be a material consideration. Finally there may reasonably be a difference in the required size due to the greater smoothness of good concrete work, amounting to 5 to 10% reduction in the mean diameter.

There can be no question that reinforced concrete is the natural engineering solution for the problem of large sewers. If reasonably designed and carefully constructed, it gives the best and cheapest sewer. In the hands of a designer not thoroughly familiar with the conditions surrounding sewer construction and maintenance, or of a contractor not experienced in reinforced concrete work, it is likely to be a dangerous material and it is a much too common occurrence that work is handled under just these conditions.

Construction. There is no other class of work in which so many difficulties surround the successful placing of reinforced concrete as in sewer construction. Sewers are usually constructed along public streets or alleys at a considerable depth below the ground, or if in shallow excavation, are likely to be along the general trend of some water course and may often cross and re-cross a running stream. For these reasons, the excavation is usually difficult and the sides of the trench are hard to support. Probably the best work can be secured in open country, where the sides of the trench can be sloped. In this case, there is no cross bracing to complicate the form work and outside forms can be used and removed. Where the sides of the trench must be vertical, it is necessary to put in hori-

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zontal planking and cross bracing as the excavation proceeds, and it is economical to use as little lumber as possible below the springing line of the sewer, as such lumber is necessarily concreted in and lost. For the same reason, it is not customary to use outside forms for the lower portion of the work.

When the excavation is complete, the invert is concreted. In rock or in dry ground, this can be done efficiently, but if water or mud is present, a portion of the concrete is sure to be unsatisfactory. With very bad bottom, it is often necessary to place a 'raft' of extra concrete and allow it to set before attempting to place reinforcement. If there is a possibility of such conditions arising, good practice will provide for this work in both specifications and estimate, and also for underdrains to prevent damage to the new concrete from water flowing from the trench ahead. Unless the specifications provide for a temporary and expensive cessation of work after the concrete in the invert is placed, there will be quite an amount of passing over and across the new invert while the concrete is setting. Exposed bars left for splicing are likely to be bent and jarred and their bond value in the invert concrete decreased. Also, because of these stub bars, it is usually impracticable to protect that portion of the invert from dirt and rubbish. While it is generally the custom to leave the sides of the invert rough in order to furnish a bond with the arch, it is an open question whether the finishing of this concrete smooth is not the lesser evil, as it can then be cleaned thoroughly and efficiently before additional concrete is laid.

Before the arch forms are set, it is necessary to remove cross bracing up to the crown level, and it must be replaced with verticals bedded in the new invert and cross-braced above the crown. Even with the most careful work, this will produce some disturbance with the sides of the trench and may even allow a bulging of the side plank sufficient to protrude within the neat measurements of the sewer. To widen and rebrace the section from the surface down may be expensive and hazardous as well as disorganizing, and the engineer often faces the problem of modifying the section instead. I recall instances where the contractors have even asked permission to fill the whole trench to the top of the sewer with concrete at their own expense, rather than to attempt the re-excavation, and the construction engineer must be able to decide whether the deficiency in thickness at the sides can be compensated in this manner.

Collapsible steel forms are usually favored for the arch. If kept well cleaned and oiled they produce the best interior surface, but well-made wooden centres carefully planned will result in more satisfactory work. The choice will usually depend on the contractor's organization and schedule, as greater progress with one outfit can be secured if the collapsible forms are used.

Under the conditions prevalent in sewer work, the setting and holding of the arch reinforcement in accurate position is especially difficult. The importance of accuracy is rarely appreciated by foreman and laborer. When properly set, the rods are difficult to hold during concreting, as it is often necessary for the men to stand on the reinforcement while spading the concrete. The purchase of special chairs or holders for the reinforcement is usually advisable.

Placing the concrete is made especially difficult because of the double mat of reinforcing bars, which tend to break up the stream of concrete and to cause separation of the aggregate. The concrete is also likely to be lowered in quality by an almost unavoidable leakage of water. The concrete is also contaminated to some extent by earth and rubbish knocked from the surface into the forms. Even in the best regulated work, small slips of earth between the side planking will occur. It is possible that portions of the clay or loam may be churned into the concrete before it can be cleaned out from between the tangle of reinforcement.

In view of the unavoidable contingencies to be expected in sewer construction I would recommend to the designer the following:

1. Use the best grade of concrete and considerable excess of mortar.
2. Do not give concrete a greater stress than 450 lb. per sq. in., unless the construction conditions are to be exceptionally favorable.
3. The concrete cover outside of the steel should be at least two inches.
4. Use a minimum thickness of concrete of about nine inches unless the work is close to the surface, or is to be built under very favorable conditions, and increase this minimum and also the cover over the steel if the conditions are likely to be unfavorable.
5. Specify the setting of the reinforcement with especially designed holders. These might be made of cast-iron and left in the concrete.
6. If there is any possibility that the trench will be very wet or mucky, provide for a sub-base of concrete and provide means of separating the trench excavation from the concrete work, if possible.
7. To secure a concrete that will flow into place with the least assistance, a specification for a 2½ or a 3-minute mix should be seriously considered, also the use of hydrated lime. This would give also a denser and more waterproof concrete and might be a considerable factor in prolonging the life of the reinforcement.
8. Provide for a lining of vitrified brick for the invert, or at least provide an excess internal area to allow for such a lining at some later date.
9. Specify precautions during cold weather. Concrete can be placed satisfactorily and economically at even a zero temperature, if proper precautions are taken. It should be noted, however, that it is quite easy to over-heat the finished concrete and to drive out a portion of the water. In the St. Louis work, it has been customary to heat the water by turning ex-

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haust steam into the water-tank whenever the temperature goes below 40° or whenever there is frost in the materials. In colder weather, steam-coils are used in the sand-storage piles and often in the piles of coarse aggregate. It is also customary in freezing weather to place salamanders inside the arches and to hang tarpaulins at each end of the unit constructed. The top of the sewer is protected generally by a covering of tarpaulin or plank, on top of which manure is piled.

Loading. The loads to be considered are first, direct weight of the earth filling; second, horizontal or inclined pressures induced by the weight of this filling and the adjoining earth; third, pressures due to transmitted surface loads. The relative values of these pressures will depend on the depth and size of the sewer and on the use to which the ground surface may be put.

Vertical Loads. It is always safe and usually reasonable to design for vertical loads equal to the full weight of the superimposed earth. Recent investigations of small sewers and pipes have shown that, due to some arching action of the earth itself, the full dead weight is not always applied to the sewer. The allowable reduction, however, is small until the depth of the fill is at least equal to the width of the trench and would only amount to about 25% when this depth is twice the width. The work of Marston and Anderson indicates that for depths of 10 to 15 times the width, only 30 to 40% of the load is carried by the sewer. For a sewer more than 8 ft. in width, the depth of cover will rarely exceed twice the trench width, so that the reductions are hardly worth taking into account. There must also be reasonable doubt whether gradual settlement does not finally increase the weight on the sewers considerably above the values given.

Horizontal Pressure. There is so much doubt as to the correct values of horizontal pressures, even for a given soil condition, and the pressures will vary so greatly in the different soils that the designer can only attempt to make a safe guess at the correct amounts to be used. According to Rankin's theory, the intensity of horizontal pressure cannot be less than one-third of the intensity of vertical pressure for a particular depth. In ordinary clay it is customary to consider it as one-half of the vertical. For saturated ground, the earth will approach the condition of a fluid and the horizontal and vertical pressures would be equal.

Surface Loads. Where sewers are constructed in city streets, the heaviest surface load would be the weight of a road roller, and this might be taken as 15 tons on an area of 5 sq. ft., at the surface, distributed downward at an angle of 30° with the vertical. At a depth of 10 ft. this would be approximately equal to 200 lb. per sq. ft. on an area of 11 by 15 ft., or roughly equivalent to an additional 2 ft. of fill. If there are railroads crossing the line of the sewer, or if it seems at all possible that such roads may be built, the sewer should be designed for locomotive loading in the same way. A fair value for this loading would be 80 tons on an area of 10 by 20 ft. at the surface. Distributed as above, this would be equivalent to about 300 lb. per sq. ft. over an area of 20 by 30 ft., at a 10-ft. depth and would give the same pressure as 3 ft. of additional fill.

For very light cover, these values would, of course, be increased, and it might even be reasonable to provide for impact, but for depths of cover of 6 ft. or more, it is usually satisfactory to treat such loads as additional weight of earth and allow them to increase both the vertical and the horizontal pressures. Allowance for foundations and for piles of material may be handled in the same manner.

Combination of Loading. For final conditions, that is, after the backfill has reached a state of settled equilibrium, the sewer will be subject to a direct combination of horizontal and vertical pressures. It should be noted that the greatest bending moments in the arch will be due to vertical loads alone. Horizontal pressures usually induce moments of the opposite kind. The combination of vertical and horizontal pressures, therefore, while increasing the direct normal compression in the arch, will give smaller bending moments than those from the vertical loads. While the stress in the arch may finally reach the values derived from a proper combination of the two classes of forces, yet it is quite common for the sewer to be subject to pressure of one kind only during the construction period. Examples of this are as follows:

1. A trench is excavated through hard clay which requires little bracing and will stand vertically for some time. The trench is backfilled with the same material. Then the full weight of the backfill may act vertically on the arch for some time before the sides of the trench finally slip and give also a horizontal pressure.

2. In the example above, the sides of the trench may cave against the sewer before the backfill is placed, producing heavy horizontal pressure and bending moments of reverse character.

3. A trench through soft ground is held by sheet piling. When this piling is pulled there may be an appreciable time before the earth at the sides closes in and fills the void left by the piling. During this time the vertical loads only will act.

4. In the above example, if the sheet piling is drawn before the backfilling is started, the earth at the sides may move in and produce horizontal pressure with very little vertical load.

Loads of these kinds will occur only while the arch is new, possibly before the concrete has attained more than half of its normal strength. If the design contains a factor of safety of four for combination of pressures, and the concrete is only 10 or 15 days old, the arch would be about on the point of failure for vertical loads.

It would seem, therefore, that the design should provide for vertical loads alone, or at least in combination with a small horizontal pressure on the arch only (not

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against vertical side-walls). This loading will be critical and from it the dimensions of the concrete and one set of reinforcements will be determined. The arch so determined should then be designed for horizontal pressure in combination with as little vertical loads as may seem possible. From this the reverse reinforcement may be calculated. Finally it is of interest to compute the stresses under normal combination of the two.

Design. The simplest case of arch design occurs when the sewer is built in a rock cut. In this instance, that portion above the rock may be taken as an arch with fixed ends, provided that the reinforcement extends well below the rock level. Where the sewer rests on rock or other incompressible material, the arch may still be treated as fixed, if sufficient mass is given to the invert to resist the overturning moment in the side-walls.

If the sewer is constructed in soft or compressible soil, the whole section, including the invert, should be treated as an elastic bent beam and the loading must include an upward pressure on the invert equal to the total vertical load.

A number of methods have been published for the analysis of the elastic arch. Of these the simplest is that presented in Green's 'Trusses and Arches,' giving bending moments in the parabolic arch for unit loads. Green also presented constants for the semi-circular arch. Green's constants for the semi-circular arch have been extended by A. E. Lindau,‡ and put into the same tabular form as was originally given for the parabolic arch. Green's analysis is based on a constant ring thickness. It is not correct for the usual case in which the arch increases in thickness from crown to springing-line and some idea of the error involved is given in Lindau's paper. Although inaccurate, this method is convenient, in that by its use we are able to calculate moments directly from the loading without the previous assumption of an arch thickness. For smaller sewers and where the variation in ring thickness is slight, it is sufficiently accurate.

In my own practice, this method has been developed into a set of formulae applicable to the semi-circular arch. These formulae give the moment at each 10° point in terms of the mean radius of the arch and of the depth of fill over the crown. In the more important work, these formulae are used in order to determine approximate dimensions for an arch which is later to be analyzed by one of the more accurate methods. As the accurate methods must be applicable to all shapes of arches and variations in thickness, it is impossible to reduce them to any very simple form.

A full theoretical description of the subject is given in Howe's 'Symmetrical Arches' and a simplified description and method of application is presented in Turneaure and Maurer's 'Principles of Reinforced Concrete.' The best practical summary of all methods and several excellent examples are to be found in Metcalf and Eddy's 'American Sewerage Practice,' Volume I.

‡Transactions American Society of Civil Engineers, Vol. 51.

In detailing the arch from the calculated bending moments, it will usually be found advisable to use two full sets of reinforcement, that is, on the inner and outer face. If it were known positively that reverse moments could never occur, for example, if it were impossible in the case of a semi-circular arch that the horizontal force could predominate, it would be reasonable to omit a portion of one set of reinforcement or possibly to cross one set over from the inner to the outer face. Generally this cannot be insured and the full reinforcement should be used even if it is only an added factor of safety and for the sake of standardization. Another reason why the arch cannot be designed too closely is that, if multiplicity of sections is to be avoided, any particular section must be designed for variations of loading over a considerable range.

In the St. Louis work, where a considerable length of one-size sewer and fairly constant soil conditions occur, it has been the practice to design a section for each 5 ft. in depth of loading and to detail these sections for soft-ground foundation, for hard bottom and for deep rock-cut. A designer should not follow the calculated thickness of the arch too closely, since some consideration must be given to the shape of the outside as well as of the inside of the sewer. For example, if the sewer is to be built in a trench with vertical sides, it would be found much simpler to make the outside of the sewer vertical to some point above the springing-line of the arch rather than to carry a small batter all the way to the bottom of the sewer. This is because of the fact that it would cost less to fill in the small wedge-shaped space with concrete than to attempt to place and remove outside forms in the limited space available.

There seems to be no uniformity in practice as to the longitudinal reinforcement. A certain amount of steel is usually required in this direction to properly tie in the transverse bars and ½ or ¾-in. bars are often used spaced about 2 ft. centre to centre in both faces. If the sewer is to be constructed in hot weather, and particularly if it is in a shallow cut, it might be advisable to increase the amount of longitudinal steel in order to distribute shrinkage stresses, but under other conditions this seems hardly necessary as the range of temperatures in the completed sewer is small, probably between 40°F. in winter to 70°F. in summer, unless steam or hot wastes are permitted to enter.

Reduction in the typhoid-fever death-rate due to the use of hypochlorite of lime in treating the water supply is shown by statistics given by *The Canadian Engineer*. Before using hypochlorite of lime, the death-rate per 100,000 from typhoid fever in the cities of Baltimore, Cleveland, Des Moines, Erie, Evanston, Jersey City, Kansas City, and Omaha ranged between 18.7 and 42.5%. After the use of the disinfectant, the death-rate dropped to between 9.3 and 22.8. The proportionate reduction ranged from 35 to 72%.

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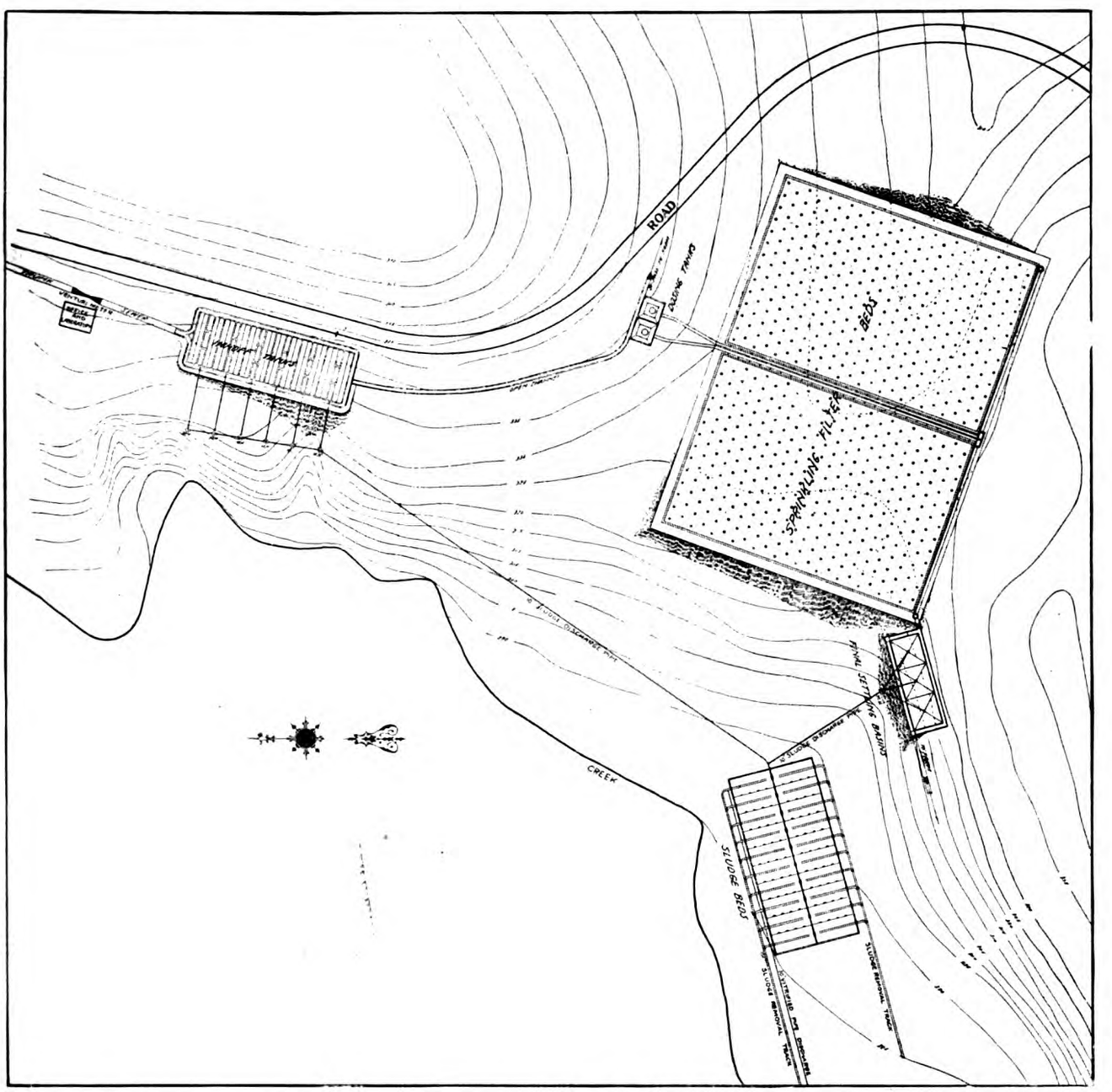
Sewage Disposal for Cities of Pasadena, South Pasadena, and Alhambra

In January, 1915, the cities of Pasadena, South Pasadena, and Alhambra entered into an agreement looking toward the construction of a joint sewage-disposal system, and appointed a Board of Engineers consisting of the city engineers of the three cities, R. V. Orbison of Pasadena, John MacMillan of South Pasadena, and Charles E. Hewes of Alhambra to report on the entire question. This report was submitted to the governing bodies of the three cities on March 27, 1916.

The report first discusses the various methods of sewage disposal as well as the different parts of a complete sewage-disposal system, including single-story septic tanks, two-story Imhoff tanks, screens, intermittent sand filters, sprinkling filters, contact beds, and settling basins. Three general plans for the disposal of the sewage of the three municipalities were considered: first, an outfall sewer to the Pacific Ocean; second, the construction of a purification plant at a suitable point and the disposal of the effluent into the Rio Hondo river; and third, the construction of a treatment plant and the purchase of sufficient land for a sewage-farm to take care of the effluent.



PLAN OF PROPOSED PLANT.

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The present population to be served is 60,000 and it is estimated that the population in 1956 will be 300,000. An outfall sewer that would be adequate for 40 years is recommended. The sewer would be 26 miles long and from 45 to 66 in. diam. according to the grade. The cost is estimated at $931,752. On account of the shore between San Pedro and Alamitos bay being fairly well inhabitated, the outfall should discharge at some point east of Alamitos bay. Even here it would not be feasible to discharge untreated sewage into the ocean. Therefore the cost of an Imhoff clarification plant, capable of handling the sewage of the present population, about $75,000 should be added, making the total cost of this method of sewage disposal slightly over $1,000,000. The final objection to the plan, however, is the inadvisability of wasting so much water in a country where water has such a high value for irrigation purposes, and where there is still a great deal of unirrigated land sufficiently remote from thickly-settled districts, so that sewage irrigation would be unobjectionable.

On account of the small flow of the Rio Hondo during a large part of the year, and its use for bathing and other purposes, all sewage would have to be thoroughly treated before being discharged into the stream. The sewage would be wasted as far as irrigation is concerned, just as with the first method of disposal. For these reasons the second method is not discussed in detail in the report.

The third method, or the construction of a purification plant and the utilization of the effluent for irrigation is the one recommended. Six hundred acres about three miles south of Alhambra has been purchased for a sewer-farm. The proposed outfall sewer, which is to be large enough to handle the sewage of 300,000 people will run from the northwest corner of the Pasadena sewage-farm, 3.48 miles to the new sewage-farm. The diameter will be 45 and 48 in. according to the grade and the amount of sewage to be handled, since a part of the sewage of Alhambra will join the outfall sewer some distance below the starting point. The system would handle domestic sewage only.

In the design of the treatment plant, it is recognized that while ordinary clarified sewage can be used on the farm itself, or sold to near-by ranchers, there may be times when it will be advisable to discharge the effluent into natural drainage channels. At such times a high state of stability in the effluent will be necessary, and since a purification plant must be in continual operation to obtain the best results, such a plant must be provided in this case.

In the plant proposed, the sewage would first pass through a coarse bar-screen and then flow through Imhoff tanks. These tanks would be six in number, each 62 ft. long, with a sectional area of 182.52 sq. ft., and would each be able to care for the sewage of 10,000 people. For the average discharge the detention period would be three hours. For the maximum it would be one hour and twelve minutes. The velocity in the tanks for the average discharge would be 20 ft. per hour.

From the Imhoff tanks the sewage would flow in an open channel to two dosing tanks, each of 18,000 gallons capacity, and from there to the sprinkling filters. These are to have an average depth of 6.75 ft. from the rock to the floor and of 6.25 ft. above the underdrainage system. A secondary clarification tank of the Imhoff type is also to be provided. The sludge is drained from the Imhoff tanks and is dried on beds having an area of 21,000 sq. ft. The capacity of the various parts of the plant could be increased with the growth in the population to be served.

The cost of the entire project is estimated as follows:

Outfall Sewer	
7100 lin. ft. 45-in. brick circular sewer	$ 28,400.00
11,300 lin. ft. 48-in. brick circular sewer	49,917.00
40 manholes, average depth 12 ft.	2,400.00
Venturi meter, 8 by 30-in., complete	1,500.00
Bar-screen and chamber	100.00
Total	$ 82,317.00
Imhoff Tanks	
Excavation, 8800 cu. yd.	$ 6,600.00
Concrete, 1935 cu. yd.	22,475.00
Inner partition walls, Hy-rib cement plaster	3,550.00
Sludge-pipe and fittings, valves, gates, etc.	3,100.00
Six brick manholes	300.00
Water system	900.00
Total	$ 36,925.00
Sprinkling Filter	
Excavation, 18,180 cu. yd.	$ 6,364.40
Exterior walls—10,241 sq. ft.	1,740.97
Reinforced concrete walls	3,210.00
Floor system	31,620.00
Channels	476.00
Manholes	300.00
Effluent collectors	1,081.20
Distribution system	22,848.00
Forty-eight 12-in. hub-end gate-valves	1,680.00
Two 24-in. shear gates	276.00
Sprinkling nozzles, 648	1,101.60
Crushed rock, 31,868 yd.	71,703.00
Total	$142,401.17
Final Settling Basins—Imhoff Type	
Excavation, 2571 cu. yd.	$ 1,928.00
Concrete, 584 yd.	6,583.00
Influent pipe, 36-in. concrete	448.20
Inner partition walls, Hy-rib cement plaster	1,520.05
Effluent pipe 36-in. concrete	422.00
Seven manholes	350.00
Cast-iron pipe and fittings and gate-valves	385.00
10-in. vitrified pipe	90.00
Water system	250.00
Total	$ 11,976.25
Sludge Beds	
Excavation, 1000 cu. yd.	$ 300.00
Concrete walls (plain)	825.00
Wooden partition walls	165.00
Underdrainage system	500.00
Track, switches, and two cars	2,181.00
Sludge-pipe and valves	458.00
Sand, 133 yd.	200.00
Rock, 652 yd.	1,304.00
Total	$ 5,933.00

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MISCELLANEOUS ITEMS

Sludge-pipe, tanks to beds	$ 640.00
Water-pipe and fittings about plant	635.00
Water-main, south line tract No. 786 to plant	2,310.00
Open channel from Imhoff tanks to dosing tank	1,050.00
Total	$ 4,635.00

DOSING TANK

Two 30-in. Miller siphons complete	$ 2,500.00
Excavation, 710 yd.	355.00
Concrete, 109 yd.	886.00
	$ 3,741.00
Laboratory building	1,000.00
Equipment	500.00
Total	$ 5,241.00
Total cost of entire plant and outfall sewer, exclusive of land	$289,428.42
Plus 10% engineering, inspection, miscellaneous	28,942.84
Total	$318,371.26

Plugging blow-holes in castings that have to be electroplated may be done as follows: Drill into the hole with a bit smaller than the blowhole, and drive into it a piece of copper wire, leaving the end projecting, and then rivet it down so as to fit the cavity. It is unnecessary to drill a hole that will cut out the entire blowhole. The surplus copper can easily be filed off even with the casting.—*Mechanical World.*

Engineers' Note Book

CHART FOR DETERMINING VELOCITY AND DISCHARGE IN EARTH DITCHES

By George Henry Ellis*

The accompanying chart may be used for computing the velocity and discharge in unlined earth ditches 10 ft. wide on the bottom. Quantities have been computed by Kutter's formula, n being taken as 0.0225, an average value for earth canals in fair condition.

Thus for a canal 10 ft. wide flowing 2 ft. deep, with a slope of 0.00045 or practically 2.3 ft. to the mile, the velocity is found by interpolation to be approximately 1.75 ft. per second and the discharge 50 cu. ft. per second. For a canal flowing 3 ft. deep, with a slope of 0.00025 practically 1.3 ft. per mile, the velocity by interpolation is 1.7 ft. per second and the discharge is 80 cu. ft. per second. Again, given a canal with a slope of 0.0006 or 3 ft. to the mile; required the depth of water to give a discharge of 25 cu. ft. per second. By interpolation the depth of water is found to be approximately 1.3 ft. The corresponding velocity is found to be approximately 1.55 ft. per second.

The diagram may also be used to solve such problems as, given a canal 10 ft. wide in which it is desired that the velocity be 2 ft. per second, what is the greatest depth that can be permitted in the canal without delivering more than 120 ft. per second and what would be the corresponding slope? The depth is found to be 3.5 ft. and the slope 0.0003 or 1½ ft. to the mile.

*Fort Shaw, Montana.

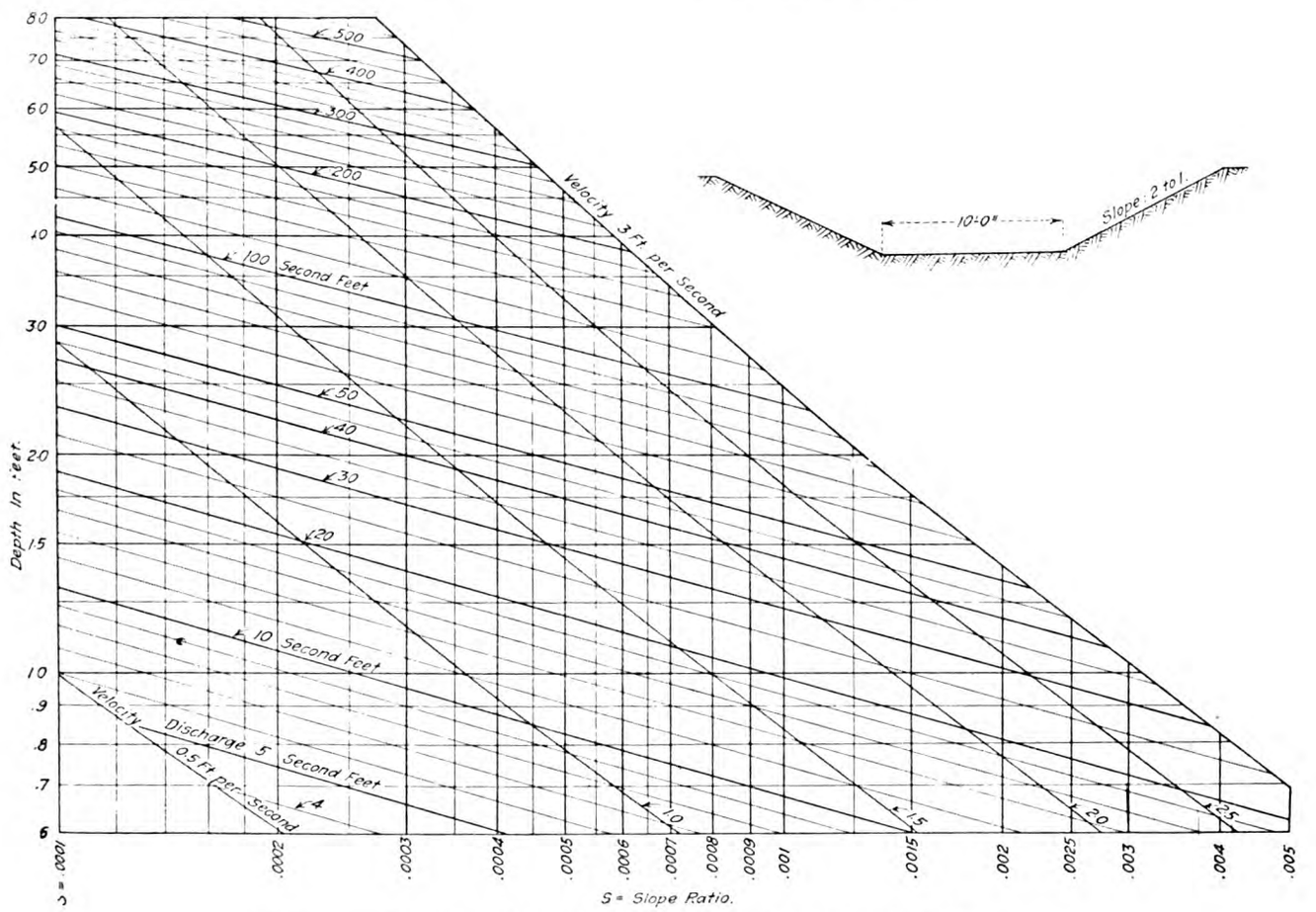

CHART FOR DETERMINING VELOCITY AND DISCHARGE IN EARTH DITCHES 10 FT. WIDE.

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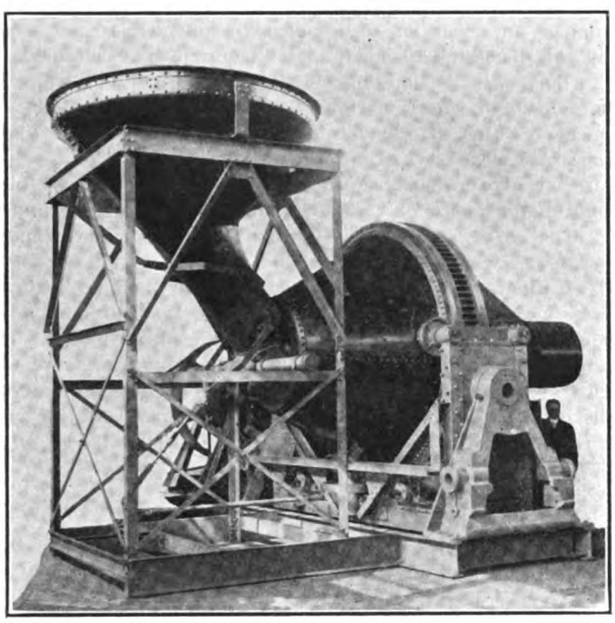
Industrial Progress

LARGEST CONCRETE MIXERS IN THE WORLD

The ordinary concrete contractor considers a 1-yd. mixer about as large as is necessary for his work, but it sometimes happens that conditions as to necessary output in a given time and amount of space available make it advisable to use larger-sized mixers. The Hardaway Contracting Co. of Washington, D. C., was recently awarded a contract for a concrete dam at Salisbury, North Carolina, which required them to pour 1,000,000 cu. yd. of concrete at the rate of 60,000 cu. yd. per month. It was found that four 2-yd. mixers would take up too much lateral space and it was decided to use two 4-yd. mixers.



VIEW OF MIXER.

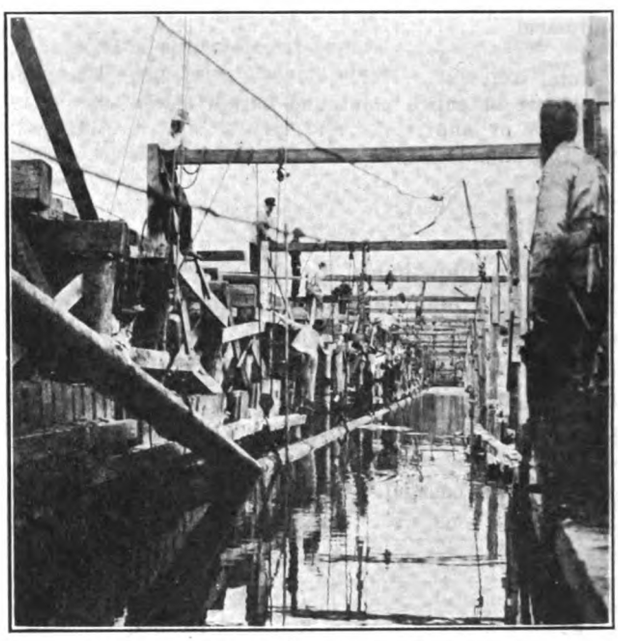
The mixers, one of which is shown in the accompanying photograph, were made by the T. L. Smith Co. of Milwaukee. Each machine is mounted on steel skids with a batch-hopper supported by a steel frame. The mixer itself is power-tilted and has an Allis-Chalmers clutch-pulley. The weight of the machine is 46,000 lb. The mixer drum is made of ⅜-in. steel. The inside diameter of the drum ring is 9 ft. 6 in. The mixers are the largest in the world and are twice the size of any of those used on the Panama Canal.

WELDING OIL AND GAS MAINS BY THE OXY-ACETYLENE METHOD

During the last few years the use of welding instead of screw or flange connections for laying gas and oil lines has come into prominence. Recently two 10-in. gas-mains were laid across the Brazos river at Waco, Texas, using this method.

The entire river bottom at the crossing was covered with about twelve feet of quicksand. Below this there was eight to ten feet of coarse sand and gravel overlying the bedrock. A trench lined with sheet-piling was excavated to the gravel. The 20-ft. lengths of gas-pipe were welded on the shore into 100-ft. sections, using the oxy-acetylene method. As beveled-end pipe had not been ordered, it was necessary to set the pipe-lengths about ⅛-in. apart so as to make a butt-weld, using Norway iron welding-wire as a filler. It required about 45 minutes to make each weld on the unbeveled pipe. In making a welded joint on 10-in. steel pipe with the ends beveled at a 45-degree angle, such as is now furnished by several pipe manufacturers, about 30 minutes is required, using 35 cu. ft. of compressed oxygen and 21 cu. ft. of compressed acetylene. Fourteen ounces of filling material is required, making a total cost of $1.10 for each joint.

These welds were first tested for strength by placing a block under each joint. The weight of two men was supported, one at either end, without affecting the joint, in spite of the leverage of the combined weight of the pipe itself and of the men at the ends. Each weld was then subjected to a pressure of 90 lb. per sq. in. without leakage.



COMPLETED LINE IN TRENCH BEFORE SINKING.

After the 100-ft. lengths of the submarine section of the pipe had been welded in the pipe-trench, at the side of the river, they were pulled out over the falsework used in constructing the trench and the 100-ft. sections were welded. The pipe was then lowered to the water-surface and weights were attached to sink it to the bottom of the trench.

The entire distance across the river was 550 ft. The work was done by the Phoenix Construction Co. of New York, under the direction of B. Diem, engineer. The oxy-acetylene cylinders were furnished by the Prest-O-Lite Co. of Indianapolis.

Book Reviews

SIX-PLACE LOGARITHMS. By Horace Wilmer Marsh. P. 155. John Wiley & Sons, Inc., New York. For sale by the MINING AND SCIENTIFIC PRESS. Price, $1.25.

This is a well-printed book of six-place logarithms arranged in the usual way. The table of logarithms of numbers has the first three figures of the number in the margin. Columns across the page give the fourth figure. The tables of logarithmic sines and tangents are figured for ten-second intervals. Proportional parts for interpolation are given in the tables for both the numbers and the trigonometric functions. There is also a seven-place table of lengths of circular arcs and a few miscellaneous mathematical tables. There is a short chapter of instruction for the use of the tables, which is entirely correct as far as the tables themselves are concerned,

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but which might give the novice the impression that logarithms must necessarily be to the base 10. The book will be found of value in the class-room, drafting-room, and office, rather than in the field. Since four-place tables are usually sufficient in the field, this is not a matter of importance.

MANUFACTURE OF GASOLINE, AND BENZENE-TOLUENE FROM PETROLEUM AND OTHER HYDROCARBONS.. By W. F. Rittman, C. B. Dutton, and E. W. Dean, with bibliography compiled by M. S. Howard. P. 262. Ill., index. Bulletin No. 114, U. S. Bureau of Mines, Washington, D. C.

This is the first authoritative statement by the engineers of the U. S. Bureau of Mines regarding the Rittman process. Part I is devoted to a general discussion of the 'cracking' of oils. Attention is called to the altered conditions that have changed the maximum demand for petroleum products from kerosene to gasoline, and to the tendency for consumption of petroleum products to outstrip production. The various 'cracking' processes are reviewed. Aromatic hydrocarbons are discussed. The preliminary experiments of the Bureau of Mines in developing a process which would increase the yield of gasoline from crude oil, and make possible the production of benzene, toluene, and other aromatic hydrocarbons is then described in detail. Part II deals with the large-scale development of the benzene-toluene and gasoline processes. The benzene-toluene process was developed in conjunction with the Aetna Explosives Co. of Pittsburg, Pennsylvania. The best results were obtained with temperatures between 600 and 750 C. and a pressure of 150 lb. From 45 to 60% of the original oil is turned to fixed gases. From 3 to 5% becomes carbon. About 10% of the original oil is recovered as creosote oil and pitch. The remainder is divided between benzene, toluene, xylenes, and gasoline. The equipment for the gasoline process is practicably the same as for the benzene-toluene process, the method of using it being somewhat different. A sufficient number of tests of the gasoline process were made at the benzene-toluene plant to enable the engineers of the Bureau of Mines to judge what its actual commercial working value would be. Best results in the gasoline process are obtained with a temperature between 500 and 575 C. and a pressure of 250 lb. From 25 to 30% may be obtained from most oils with each run, and the residuum run again until 80 to 90% of gasoline is usually recovered in three or four runs. The book includes an unusually complete bibliography.

Engineering Societies and Conventions

IDAHO SOCIETY OF ENGINEERS. Ira F. Schaffner, secretary, Boise.

Los Angeles Section of AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Ford W. Harris, secretary, 1029 Higgins building.

Los Angeles Section of AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Edward Woodbury, secretary, 255 East 3rd street.

OREGON SOCIETY OF ENGINEERS. Orrin E. Stanley, secretary, room 409, City Hall, Portland.

Portland Section, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Paul Lebenbaum, secretary, 45 Union Depot.

Portland Association of Members of AMERICAN SOCIETY OF CIVIL ENGINEERS. Charles McGonigle, president, care Western Sheet Metal Works.

San Francisco Association of Members of AMERICAN SOCIETY OF CIVIL ENGINEERS. E. T. Thurston, Jr., secretary, Mechanics Institute building.

San Francisco Section of AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Carl F. Braun, secretary, Hooker & Lent building.

San Francisco Section of AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. A. G. Jones, secretary, 811 Rialto building.

Southern California Association of Members of AMERICAN SOCIETY OF CIVIL ENGINEERS. W. K. Barnard, secretary, 701 Central building, Los Angeles.

The bi-monthly meeting and dinner of the San Francisco Association of Members of the AMERICAN SOCIETY OF CIVIL ENGINEERS was held on the evening of April 18 at the Palace hotel. The question of the removal of the New York headquarters of the Society to the building of the United Engineering Societies was discussed, as was also the question of preparedness and the co-operation of civilian engineers in time of war. M. C. Couchot called the attention of the Society to the removal of Leon H. Nishkian from the city department of building permits. The resolution given below was adopted and a committee composed of H. J. Brunnier, M. C. Couchot, and J. D. Galloway were appointed to take such further action as might be deemed advisable in calling the attention of the public to the matter. The committee met and addressed the following letter to the Board of Public Works.

SAN FRANCISCO, April 22, 1916.

To the Board of Public Works of the City and County of San Francisco,

GENTLEMEN:

Referring to the recent removal of Mr. Leon H. Nishkian from the department of building permits, the subject was discussed at length at the last meeting of the San Francisco Association of Members of the American Society of Civil Engineers and the following resolution was unanimously adopted:

"*Resolved*: That the San Francisco Association of Members of the American Society of Civil Engineers expresses its confidence in the impartial, trustworthy, fearless, and competent way and manner in which Mr. Leon H. Nishkian has conducted the work in his office as structural engineer to building permits department and our regrets as to his removal from his position."

As chairman of a committee appointed for this purpose, I am transmitting to you this resolution.

Your very truly,
H. J. BRUNNIER.
Chairman of Committee.

Coming Conventions

Air Brake Association. Annual convention, Atlanta, Georgia, May 2-5. E. M. Nellis, secretary, 53 State street, Boston.

American Iron and Steel Institute. General meeting, New York, May 26-27. J. T. McCleary, secretary, 61 Broadway, New York.

American Society of Civil Engineers. Annual meeting, Pittsburg, June 27-30. Charles Warren Hunt, secretary, 220 West 57th street, New York.

American Society for Testing Materials. Annual meeting, Atlantic City, New Jersey, June 27-July 1. Edgar Marburg, secretary, University of Pennsylvania, Philadelphia.

American Water-Works Association. Annual Convention, New York, June 5-9. J. M. Diven, secretary, 47 State street, Troy, New York.

American Supply and Machinery Manufacturers' Association. Annual convention, Pittsburg, May 10-12. F. D. Mitchell, secretary, 1501 Woolworth building, New York.

Annual Conference on Weights and Measures. Under auspices of U. S. Bureau of Standards. Washington, D. C., May 23-26. L. A. Fischer, secretary, U. S. Bureau of Standards, Washington, D. C.

International Railway Fuel Association. Annual meeting, Chicago, May 15-18. J. G. Crawford, secretary, 547 West Jackson boulevard, Chicago.

Master Boiler Makers' Association. Annual meeting, Cleve-

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land, May 23-26. H. D. Vought, secretary, 95 Liberty street, New York.

National Conference on City Planning. Annual convention, Cleveland, June 5-7. Flavel Shurtleff, secretary, 19 Congress street, Boston.

National District Heating Association. Annual convention, New York, May 16-19. D. L. Gasgill, secretary, Greeneville, Ohio.

National Electric Light Association. Annual convention, Chicago, week beginning May 22. T. C. Martin, secretary, 29 West 39th street, New York.

National Fire Protection Association. Annual meeting, Chicago, May 9-11. Franklin H. Wentworth, secretary, 87 Milk street, Boston.

Railway Development Association. Annual meeting, New Orleans, May 9-11. H. O. Hartzell, secretary, Baltimore & Ohio Railroad, Baltimore.

Society of Railway Club Secretaries. Annual meeting, Atlantic City, New Jersey, June 16-17. H. D. Vought, secretary, 95 Liberty street, New York.

Personal

A. M. McCray has been appointed city engineer of Hollister, California.

Frank Lotz has been appointed city engineer of Vader, Washington.

S. A. Cobb has been appointed highway engineer of Clackamas county, Oregon.

B. K. Stroud sails on May 2 for Sydney, Australia, where his address will be care Overall & McCray, Limited.

F. L. Bixby, irrigation engineer for the Federal Department of Agriculture, is making irrigation investigations in Nevada, with headquarters at Reno.

I. D. Goodner, formerly of Aurora, Nevada, has been appointed consulting engineer for the Paradise irrigation district, in Butte county, California.

Isaac S. Voorhees, who has been connected with the Klamath project of the U. S. Reclamation Service has been transferred to the Denver office of the Service.

W. H. Lynch, engineer for the U. S. Office of Public Roads, is in Reno, Nevada, assisting the commissioners of Washoe county in preparing plans for county highways.

Clyde B. Aitchison, formerly member of the Oregon Railway Commission, has been appointed director of the valuation department of the National Association of Railroad Commissioners, with headquarters at Washington, D. C.

Charles E. Strickland, of the Oregon State Engineering Department has taken charge of hydrographic work for the department on Burnt river in Baker county, in connection with the adjudication of water-rights on that stream.

The Utah Society of Engineers has elected the following officers for the coming year; president, Guy Sterling; first vice-president, C. J. Ullrich; second vice-president, W. A. Wilson; secretary, Hugh C. Lewis; treasurer, L. H. Krebs.

J. P. Newell, George C. Mason, and J. L. Stannard, all of Portland, Oregon, have been appointed by the local Association of Members of the American Society of Civil Engineers to investigate the charges of inferior work in the construction of the Montavilla sewer, recently completed in that city.

Richard W. Rea, formerly chief engineer of the Coast Culvert & Flume Co. of Portland, Oregon, has resigned in order to open an office at 412 Spalding building, in that city. He will specialize in the investigation, design, and construction of municipal water-supply, irrigation, and drainage works.

J. G. Scrugham, dean of the college of engineering at the University of Nevada, has been appointed a member of the Federal Consulting Board to make a survey of the industrial resources of that State with a view to their utilization in time of war. The California members of this board are Wynn Meredith, George W. Dickie, Charles W. Merrill, A. H. Babcock, and Edmund O'Neill.

Commercial Paragraphs

Builders Iron Foundry, represented on the Pacific Coast by Norman B. Livermore & Co. has recently sold a number of Venturi meters to the Pacific Gas & Electric Co. for use at Napa, Santa Rosa, and Son Jose.

The Calumet & Arizona Mining Co. has recently purchased six switching locomotives from the American Locomotive Co., 36 dump-cars from the Kilbourne & Jacobs Mfg. Co., and three 105-ton steam-shovels from the Osgood Company.

The Pacific Tank & Pipe Co. has moved its Los Angeles office to 910-912 Trust & Savings building, at the north-west corner of 6th and Spring streets. The company has just completed a new and larger plant at East Wilmington, conveniently situated to the harbor of Los Angeles.

H. E. Smith, H. Clay Kellogg, Clyde Butler, and I. Stukey, all of Santa Ana, California, have formed the Orange County Engineering & Construction Co. The new concern will have its headquarters in Santa Ana, and will engage in street paving and other contract work in that vicinity.

The New York State Industrial Commission recently conducted an actual fire-test of three Fenestra solid steel windows manufactured by the Detroit Steel Products Co., and as a result of this test, has pronounced the Fenestra window to be a fire-proof window answering all the requirements of the industrial code.

The National Tube Co. has issued bulletin No. 25. The bulletin is mainly devoted to photographs of important buildings in which 'National' pipe is used, but, as is usual with the publications of the company, there is a large amount of valuable technical information mainly concerning the properties of various kinds of pipe.

The Meese & Gottfried Co. has adopted the sectional form in issuing its new general catalogue. Section No. 1 of the ninth edition has been received. It treats of a portion only of the company's line of conveying, elevating, screening, and power-transmission machinery, namely, pulleys, couplings, and shafting, together with much important data, making it of permanent value to the engineer or plant superintendent. Of special interest is the descriptive matter it contains on 'short-centre' belt-drives, a departure from the usual methods of belt driving which makes it possible to install belt drives under conditions where heretofore high-speed chains alone were considered practicable.

C. L. Ross, manager for the Pacific Car Co. of Tacoma, Washington, agents for the Packard Motor Car Co., makes the following statement regarding the comparative merits of eastern and western lubricating oils: "We made a careful oil test covering eight months, using two eastern oils and a western oil made from asphalt-base crude. In spite of the fact that the Packard using the western oil was driven 3000 miles more than the other cars, it showed less wear on cylinder-walls, rings, pistons, and motor-bearings, with practically no carbon. On the other hand, both of the cars using eastern oil had large carbon deposits. There is no question in my mind about the superiority of western oil, especially in the present-day high-speed motors with their close-fitting pistons. Freedom from piston drag and from carbon are highly essential in the operation of these motors, and western oil gives just the results needed." A comparative test with light automobiles gave a similar result.

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SAN FRANCISCO, MAY 1, 1916

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CONSTRUCTION NEWS

STREET AND ROAD WORK

Anaheim, Cal.—Contract for paving Broadway has been awarded to George R. Curtis, 552 South St. Louis street, Los Angeles, for $0.1075 per square foot.

Beaumont, Cal.—Contract for the construction of sidewalks has been awarded to Highway Construction Co., San Bernardino.

Benicia, Cal.—Contract for grading at the Black bridge has been awarded to Pometta Bros. for $1634.75.

Berkeley, Cal.—Oakland Paving Co. and Federal Construction Co., who were awarded contracts respectively for improvement of Fulton street and Durant avenue, have asked to be released from signing the contracts on account of technical irregularities in the proceedings.

Cathlamet, Wash.—County engineer J. Newell has completed plans for macadamizing highway to Skamokawa and call for bids will be issued soon. Estimated cost is $15,939.85.

Colfax, Wash.—Bids will be received until 11 a.m., May 15, by A. R. Metz, county auditor, for construction of permanent highways No. 9-A and 9B, comprising 11⅓ miles of surfaced road.

El Centro, Cal.—Imperial Valley Bankers' Association has endorsed proposed bond issue of $1,000,000 for construction of county highway system.

Enumclaw, Wash.—Bids will be received until 8 p.m., May 2, by O. E. Magnuson, city clerk, for grading, and construction of pavement, curbs, and sewers on several streets.

Eureka, Cal.—Bids will be received until 1:30 p.m., May 9, by Fred M. Kay, county clerk, for clearing right-of-way for road near Blue Lake.

Everett, Wash.—Contract for construction of Bothell-Silver Lake highway has been awarded to P. G. Dunn & Co., 509 Railway Exchange Bdg., Seattle, for $114,000. Work includes 83,100 sq. yd. concrete pavement and 22,000 cu. yd. excavation.

Contract for construction of Snohomish-Cavileros Corners highway has been awarded to Mark O'Dell, Boston Block, Seattle, for $59,205. Work includes 40,524 sq. yd. concrete pavement and 14,153 cu. yd. excavation.

Contract for construction of 9222 cu. yd. concrete pavement on 41st street has been awarded to Mark O'Dell for $12,673.

Contract for construction of Everett-Silver Lake highway has been awarded to Bancroft & Morgan for $51,411. Work includes 37,566 cu. yd. concrete pavement and 5577 cu. yd. excavation.

Inwood, Cal.—Formation of road district in southern part of Shasta county is proposed. Bond issue of $150,000 for construction of highways is suggested. A. W. Smith, Cottonwood, is interested.

Los Angeles, Cal.—Board of Public Works will receive bids until 10 a.m., May 1, for the following street work: asphalt and concrete pavement, curbs, sidewalks, granite-block gutters, and vitrified-pipe storm-drains on New Hampshire avenue; asphalt and concrete pavement, curbs, sidewalks, and concrete and granite-block gutter on Kenmore avenue; asphalt pavement, curbs, concrete, granite-block and vitrified-brick gutters on Berendo street.

Board of Supervisors will receive bids until 2 p.m., May 15, for construction of 1.11 miles of 5-in. concrete pavement, 20 ft. wide, on Mint Canyon highway near Palmdale.

Contract for construction of 1.51 miles of concrete pavement near Palo Verde station has been awarded to S.-C. Contracting Co., Washington Bdg., for $19,700.

Contract for construction of 1.68 miles of oiled macadam pavement on Base Line road has been awarded to William Cazaux, 565 Gower street, for $5512.

Contract for improvement of Los Feliz avenue has been awarded to Geo. R. Curtis, 552 South St. Louis street, for $46,916.65.

Contract for construction of 6.38 miles of concrete highway on Workman Mill road has been awarded to Brashear-Burns Co., Van Nuys Bdg., for $34,648.

Marshfield, Ore.—Election will be held May 19 to vote on bond issue of $362,000 for construction of county highway system.

Napa, Cal.—Contract for improvement of Pine street has been awarded to George Errington for $2145.14. F. A. Burge bid $2167.56.

Contract for improvement of Laurel street has been awarded to F. A. Burge for $2372.65. George Errington bid $2627.52.

Following were the bidding prices of F. A. Burge, who was awarded contract for improvement of Laurel street: excavation, $0.00375 per sq. ft.; two-course asphalt macadam pavement 6 in. thick, $0.03525 per sq. ft.; concrete curbs, $0.275 per foot.

Oakland, Cal.—Bids will be received until noon, May 4, by L. W. Cummings, city clerk, for the following street work: cement sidewalks for two blocks on East 14th street and on part of East 18th stret, for three blocks on East 24th street, for four blocks on East 21st street, for one block on Hopkins street, and for two blocks on East 26th street; grading and construction of asphalt pavement, concrete curbs, and brick gutters on Madison street; for grading and construction of concrete curbs, gutters, and sidewalks, and oil macadam pavement on 35th avenue.

Bids will be received until 10 a.m., May 15, by G. E. Gross, county clerk, for construction of steel girder-span for highway under-crossing at Western Pacific Railway tracks west of Niles.

Bids will be received until 10 a.m., May 22, by George E. Gross, county clerk, for construction of reinforced concrete underpass under Southern Pacific tracks on a county highway in the Pleasanton road district.

Contract for improving 34th avenue has been awarded to Hutchinson Co., 13th and Franklin streets, at the following unit prices: excavation, $0.10 per cu. yd.; redwood curbs, $0.09 per ft.; concrete gutters, $0.11 per sq. ft.; oil-macadam pavement, $0.08 per sq. ft.; 8 by 24-in. corrugated iron and concrete culverts, $1.80 per foot.

Contract for improvement of Galindo street has been awarded to Hutchinson Co. at the following unit prices: excavation,

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$0.05 per cu. yd.; redwood curbs, $0.09 per ft.; concrete gutters, $0.11 per sq. ft.; oil-macadam pavement, $0.08 per sq. ft.; cement sidewalks, $0.09 per sq. ft.; 8 by 24-in. corrugated iron and concrete culvert, $1.80 per ft.; 3 by 3-ft. concrete culvert, $2.25 per ft.; storm-water inlets, $15 each.

Olympia, Wash.—Bids will be received until May 8 by County Commissioners for construction of 2¼ miles of macadam road on Little Rock highway. Estimated cost is $8000.

Palo Alto, Cal.—Bids will be received until 8 p.m., May 8, by city clerk, for about seven miles of street work requiring 23,077 cu. yd. excavation, 1,275,860 sq. ft. of 5-in. concrete pavement with skin coat of road oil, and 25,475 ft. of concrete curbs. J. F. Byxbee, Jr., is city engineer.

Palouse, Wash.—Contract for construction of 6-in. bituminous pavement on Main street has been awarded to Washington Paving Co., Seattle, for $32,629.

Richmond, Cal.—State Highway Commission will soon issue call for bids for construction of highway on San Pablo avenue from Macdonald avenue southerly to county line, about three miles.

Riverside, Cal.—County Highway Commission has recommended additional highway bond issue of $713,425; $25,625 for repair of washed-out roads, $140,000 for replacing washed-out bridges, $192,000 for completion of Corona-Elsinore road, $137,800 for connecting links of county highways within cities, $61,000 for surfacing Moreno-Beaumont road, and $156,500 for completion of county highway system.

Sacramento, Cal.—Bids will be received until 11 a.m., May 4, by M. J. Desmond, city clerk, for the following street work: grading, and construction of concrete curbs, gutters, and sidewalks, and asphalt pavement on concrete base on Madrone avenue; construction of sewers on V street; and construction of sewers on 34th street.

Salinas, Cal.—Contract for construction of Carmel-Monterey highway has been awarded to W. A. Dontanville for $22,923.10. Other bidders were: E. M. Price, $23,444.50; Western Construction Co., $23,941.75; Sonnicksen & Bryan, $23,967.90; and F. F. Moore, $24,415.60.

City engineer Davies has prepared plans for improvement of Front street, including concrete pavement with oil and screening surface. Estimated cost is $8998.07.

Salt Lake City, Utah.—Plans have been prepared for expenditure of $157,984 for improvements to county highways during year.

San Francisco, Cal.—Following street work has been ordered: curbs, sidewalks, and asphalt pavement on Birch street; sidewalks on Columbus avenue; curbs and asphalt pavement on Price row; sewers on Gavin, Hale, and Merrill streets.

San Jose, Cal.—Contract for improvement of 4th street has been awarded to W. M. Painter at the following unit prices: asphaltic concrete pavement on 4½-in. cement concrete base, $0.17 per sq. ft.; catch-basins, $40 each; 8-in. vitrified pipe, $0.60 per foot.

Contract for construction of asphalt pavement on concrete base on Willow street has been awarded to Raisch Improvement Co., Crocker Bdg., San Francisco, at 13c. per sq. ft. for paving, and 2½c. per sq. ft. for excavation.

Sausalito, Cal.—Town engineer L. L. Hohl has completed plans for improvement of Johnson, Pine, and Turney streets by construction of asphalt pavement and concrete curbs, gutters, and sidewalks.

Seattle, Wash.—County Commissioners will receive bids until May 16 for construction of 2½ miles of hydrauiic fill on Seattle-Duwamish highway. Work includes 130,000 cu. yd. embankment and the estimated cost is $35,000.

Stevenson, Wash.—Contract for highway work has been awarded to Porter Bros., Railway Exchange Bdg., Portland, Ore., for $54,630.

Stockton, Cal.—City clerk will receive bids until May 5 for construction of asphaltic macadam pavement and concrete curbs, gutters, and sidewalks on several streets.

Sunnyvale, Cal.—Town engineer F. P. McCray has completed plans for paving several streets. Estimated cost is $9000.

Tacoma, Wash.—Contract for construction of 8½ miles of McClellan Pass highway has been awarded to Sloan Bros., Seattle, for $50,000.

Toppenish, Wash.—Contract for grading and graveling several streets has been awarded to A. Kingrey for $2010.

Tropico, Cal.—Contract for improving Adams street has been awarded to E. Schelling, 660 West Jefferson street, Los Angeles, for $10,933.

Watts, Cal.—Bids will be received until 7:30 p.m., May 2, by A. D. Franklin, city clerk, for construction of 1200 lin. ft. of cement sidewalks on Palm drive.

Weaverville, Cal.—U. S. Forest Service will spend $71,000 on construction of highway down north fork of Trinity river to Humboldt county line, 42 miles.

Woodland, Cal.—Clark & Henery Construction Co., Sacramento, was low bidder at $0.122 per sq. ft. for construction of warrenite pavement on several streets.

SEWERS AND DRAINAGE

Auburn, Cal.—Solon Pierce, Sacramento, has prepared plans for Imhoff tank for treatment of city sewage. Call for bids will be issued soon.

Orange, Cal.—Formation of reclamation district for flood-protection of land on east side of Santa Ana river has been proposed. District would contain 2300 acres and the work would cost $25,000. J. D. Thomas, Olive, is interested.

Sacramento, Cal.—Bids will be received until May 23 by M. J. Desmond, city clerk, for construction of weir on west bank of Sacramento river near Bryte's Bend. Weir will be 2185 ft. long and will cost $460,000.

Salt Lake City, Utah.—Bids will be received until 10 a.m., May 16, by Gordon Snow, city recorder, for construction of sewer extensions. Plans from city engineer S. Q. Cannon, upon deposit of $5.

BRIDGES AND CULVERTS

Astoria, Ore.—Bids will be received until May 3 by city auditor for construction of four reinforced concrete viaducts. Total estimated cost is $200,000. Plans from G. T. McClean, city engineer, upon deposit of $15 for each set, or $45 for plans for all four viaducts.

Eugene, Ore.—County clerk will receive bids until May 8 for construction of three highway bridges, one 615-ft. trestle with draw-span over north fork of Siuslaw river and two 75-ft. bridges in other parts of the county.

Eureka, Cal.—Board of Supervisors has appropriated $2386, being the difference between the bid of Mercer-Fraser Co. for construction of State highway bridge over Eel river and the engineers' estimate, thus making it possible for the bid to be accepted by the State Highway Commission.

Goldendale, Wash.—County auditor will receive bids until May 6 for construction of one 60-ft. and one 70-ft. steel span.

Grants Pass, Ore.—Bids will be received until 1 p.m., May 3, by E. L. Coburn, county clerk, for construction of reinforced concrete bridge over Jones creek.

Montesano, Wash.—Contract for construction of Satsop bridge has been awarded to R. E. Mieth for $16,444.

Contract for construction of Wynooche bridge has been awarded to Monson Construction Company.

Riverside, Cal.—Bids will be received until 10 a.m., May 3, by Board of Supervisors for grading and construction of concrete and corrugated iron culverts on part of route No. 1, a distance of 2.35 miles. Work includes 24,330 cu. yd. excavation, 125 cu. yd. concrete, and 833 ft. corrugated iron pipe.

San Francisco, Cal.—Contract for alterations to the south leaf of the Third Street bridge has been awarded to Thomson Bridge Co., 103 Main street, for $2487.

Seattle, Wash.—Board of Public Works will receive bids until May 5 for furnishing iron and steel work for one 86-ft. Howe truss span and one 100-ft. Howe truss span for approaches to Salmon Bay bridge.

IRRIGATION AND WATER SUPPLY

Aberdeen, Wash.—Bids will be received until 5 p.m., May 31, by P. T. Clark, city clerk, for construction of 22 miles of 28-in. wood-stave pipe-line. L. D. Kelsey is city engineer.

Contract for furnishing 1,000,000 ft. B.M. of lumber for staves for pipe-line has been awarded to Vance Lumber Co., Malone, for $23 per thousand.

Colville, Wash.—Bids will be received until 8 p.m., May 2, by J. O. Hard, city clerk, for construction of 1,000,000-gallon concrete reservoir. Sawyer Bros., 410 Lindelle Block, Sponkane, are engineers.

Fort Laramie, Wyo.—Bids will be received until 2 p.m., May 22, at office of U. S. Reclamation Service, for construction of two tunnels and the concrete lining of the canal approaches to same on the Fort Laramie canal, North Platte project. Work includes 4850 lin. ft. tunnel excavation and 12,000 cu. yd. concrete in place. Work is near the Bridgeport-Guernsey line of the Chicago, Burlington & Quincy railroad in the vicinity of Fort Laramie. Particulars from U. S. Reclamation Service, Washington, D. C., Denver, Colo., or Fort Laramie.

Grand Junction, Colo.—Bids will be received until 2 p.m., May 23, at office of U. S. Reclamation Service, for construction of 3950 ft. of 60-in. wood-stave pipe for Grand Valley project. Particulars from U. S. Reclamation Service, Washington, D. C., Denver, or Grand Junction.

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Hemet, Cal.—Contract for construction of 1400 ft. reinforced concrete pipe 12 to 30 in. diam. and of 265 ft. tunnel, both for Lake Hemet Land & Water Co., has been awarded to Bent Bros. Construction Co., Central Bdg., Los Angeles.

San Francisco, Cal.—Following applications to divert water have been received by State Highway Commission:

From Albert Givan, 1525 K street, Sacramento, water from American river for irrigation in Carmichael tract. Plans include pumping plant and pipe-line seven miles long. Estimated cost is $52,250.

From John M. Akers, Sanger, water from a spring in Fresno county. Plans include pipe-line, 1½ miles long.

From Alberhill Coal & Clay Co., Union Oil Bdg., Los Angeles, water from springs in Riverside county. Plans include pipe-line 1½ miles long, costing $2500.

From John F. Mauch, Calvena, water from Honey lake for irrigation. Plans include pumping plant costing $200,000 and 22 miles of main ditch costing $400,000.

From William Wales, Woodland, water from Willow creek in Lassen county for irrigation of 50,000 acres.

From California Chief Development Co., care, Charles P. Brooks, Salt Lake City, water in Placer county for mining and milling purposes. Plans include crib and loose rock dam, pipe-line, Pelton wheel, and dynamo.

From George Allen, College City, water in Colusa county. Plans include gasoline pumping plant costing $1000.

From M. L. Hazzard, Whittier, water in San Dimas canyon. Plans include concrete diversion dam and four miles of main canal. Estimated cost is $350,000.

From H. A. Unruh, Arcadia, water from Santa Ana river. Plans include dam and distribution system costing $30,000.

From West Side irrigation district, Tracy, water from San Joaquin river. Plans include pumping plants and canals costing $285,000.

State Water Commission has granted the following permits to divert water:

To Celso Tonello, Modesto, water from Stanislaus river. Plans include gasoline pumping plant costing $2500.

To W. J. Hole, Trust & Savings Bdg., Los Angeles, water from Riverside. Estimated cost of works is $10,000.

To Blevins-Mallon Ditch Co., Colusa, water from Sacramento river. Plans include pumping plant driven by electric motor and 2½ miles of canal. Estimated cost is $11,000.

St. Ignatius, Mont.—Bids will be received until 2 p.m., May 25, for construction of canals and structures on the Flathead project, involving 220,000 cu. yd. excavation, 870 cu. yd. reinforced concrete, 3250 sq. yd. paving, 7650 sq. ft. canal lining, manufacturing and laying 6230 lin. ft. concrete pipe, laying 210 cu. yd. dry rubble wall, 4000 ft. B.M. lumber, and 110,000 lb. structural and reinforcing steel. Part of the work is from three to ten miles southwest of Polson, and the remainder from six to eight miles west of Ronan. Particulars from U. S. Reclamation Service, Washington, D. C., Denver, Colo., or St. Ignatius.

Washington, D. C.—Bids will be received until 2 p.m., May 15, at office of U. S. Reclamation Service, for furnishing steel and cast-iron sluice and regulator-gates, gate-frames, lifting devices, and accessories, and miscellaneous fabricated steel for Milk River project, Montana. Particulars from U. S. Reclamation Service, Washington, D. C., Denver, Colo., or Malta, Montana.

Contract for earthwork on Bowdoin canal and laterals on Milk River project of the U. S. Reclamation Service has been awarded to L. W. Dotson, Glasgow, Montana, for $9105.95.

Wenatchee, Wash.—Bids will be received until May 23 by W. T. Knapp, secretary Wenatchee Reclamation District, Central Bdg., for manufacture and laying of 5470 ft. of 63-in. reinforced concrete pipe.

BUILDING CONSTRUCTION

Aberdeen, Wash.—Contract for construction of stone and reinforced concrete post-office has been awarded to Henrickson & Co., Globe Block, Seattle, for $74,059.

Alameda, Cal.—Contract for steel work for Porter school has been awarded to Schrader Iron Works, 1247 Harrison street, San Francisco, for $11,800. Contract for the rest of the construction has been awarded to H. A. Klyce, Sheldon Bdg., San Francisco, for $82,137.

Bakersfield, Cal.—Bids will be received until 9:30 a.m., May 15, by James Egan, secretary board of education, for construction of school building. Plans from O. L. Clark, Brower Bdg., upon deposit of $10.

Lodi, Cal.—Contract for construction of $40,000 brick school building, with concrete foundation, has been awarded to A. Freblick, Turlock.

Maricopa, Cal.—Contract for construction of high-school building has been awarded to F. L. Gribble, Bakersfield, for $12,745.

Martinez, Cal.—Bids will be received until 11 a.m., May 15, by J. H. Wells, county clerk, for construction of building for library at Walnut Creek.

San Francisco, Cal.—Board of Public Works will receive bids until May 3 for construction of engine-house No. 8. Separate bids will be received on general construction, heating, electrical work, and lighting fixtures.

Bids will be received until noon, May 4, by Haviland & Tibbetts, Alaska Commercial Bdg., for raising, moving, or reconstructing five warehouses on the bank of Sacramento river between Knights Landing and Colusa for the Sacramento River West Side levee district.

Bids will be received until 11 a.m., May 18, at office of constructing quartermaster, Fort Mason, for construction of officer's quarters at Presidio.

Seattle, Wash.—Board of Regents of University of Washington, Henry Bdg., will receive bids until 2 p.m., May 19, for construction of political science and commerce building. Plans from Webb & Gould, Denny Bdg., upon deposit of $5.

Contract for construction of brick apartment house for Logan Commercial Co. has been awarded to Rainier Construction & Engineering Co., 541 Stuart Bdg., for $55,000.

Taft, Cal.—Bids will be received until 2 p.m., May 6, by W. S. Lierly, secretary board of trustees, for construction of high-school building. Estimated cost is $60,000. O. L. Clark, Bakersfield, is architect.

Walla Walla, Wash.—Contract for construction of reinforced concrete building for Peoples State Bank has been awarded to Washington Construction Co., Northern Bank Bdg., Seattle, for $20,000.

Washington, D. C.—Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids until May 27 for construction of building at torpedo station at Keyport, Washington. Plans from the Bureau or from the commandant of the Navy Yard, Bremerton, Washington.

RAILROAD WORK

Ellensburg, Wash.—A. Guthrie & Co., St. Paul, Minn., will build logging railroad and log timber on Teanaway river. E. L. Turner is superintendent.

North Yakima, Wash.—Contract for grading 24 miles of line on Northern Pacific extensions has been awarded to Porter & Conley, Portland, Oregon.

Pasco, Wash.—Northern Pacific Railway Co., St. Paul, Minn., is receiving bids for construction of cut-off from Grandview to Gibbon. Improvements will also be made in line from Ellensburg to Pasco, bringing the total cost of the work to about $1,000,000.

Satsop, Wash.—Bids will be received until 1:30 p.m., May 1, by Schafer Bros. Logging Co. for building 6000 ft. of trestle and grading 10,800 ft. of logging railroad.

MACHINERY AND SUPPLIES

Berkeley, Cal.—Reported sale of road roller to city was incorrect.

Butte, Mont.—Bids will be received until 7:30 p.m., April 28, by A. A. Dockstader, city clerk, for furnishing one motor-driven pick-up sweeper and one motor-driven vacuum street-cleaner.

Bids will also be received until the same time for construction of incinerating plant.

Ketchikan, Alaska.—Contract for furnishing one 6-hp. double-drum geared hoist and engine for Sentinel Island has been awarded to Fairbanks, Morse & Co. for $642. Other bidders were: Lidgerwood Manufacturing Co. $780, and Doak Gas Engine Co. $955.

Placerville, Cal.—Bids will be received until 5 p.m., May 1, by O. E. Bailey, city clerk, for furnishing 500 ft. of 2½-in. cotton rubber-lined fire-hose.

Portland, Ore.—Bids will be received until 2 p.m., May 1, by lighthouse inspector for furnishing steam and lump coal at Portland, Astoria, Ore., and Seattle, Wash., for vessels and stations in the 16th and 17th lighthouse districts.

Salinas, Cal.—Contract for furnishing fire-hydrants to city has been awarded to Water Works Supply Co., Monadnock Bdg., San Francisco, at $25.50 each for a Corey type hydrant with single opening for 2½-in. hose.

MISCELLANEOUS

San Francisco, Cal.—Bids will be received by W. H. Hart, Fort Mason, until 11 a.m., May 1, for furnishing 3,000,000 ft. B.M. Washington or Oregon douglas fir. Particulars from circular No. 178.

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Contracts Pending

Bids will be Received		See Issue of News Bulletin
May 1.	Bakersfield, Cal., Road Work	Apr. 24
May 1.	Colfax, Wash., Road Work	Apr. 17
May 1.	Fresno, Cal., Machinery and Supplies	Apr. 17
May 1.	Los Angeles, Cal., Bridge	Apr. 17
May 1.	Los Angeles, Cal., Street Work	May 1
May 1.	Newport, Wash., Road Work	Apr. 17
May 1.	Odessa, Wash., Bridges	Apr. 3
May 1.	Redwood City, Cal., Street Work	Apr 17
May 1.	San Bernardino, Cal., Building	Mar. 27
May 1.	San Francisco, Cal., Irrigation	Apr. 24
May 1.	San Francisco, Cal., Supplies	Apr. 17
May 1.	Santa Barbara, Cal., Bridge	Apr. 24
May 1.	Santa Barbara, Cal., Road Work	Mar. 20
May 1.	Satsop, Wash., Railroad Work	May 1
May 1.	Seattle, Wash., Miscellaneous	Apr. 17
May 1.	Seattle, Wash., Road Work	Apr. 17
May 1.	Vallejo, Cal., Sewers	Apr. 24
May 2.	Burbank, Cal., Building	Apr. 24
May 2.	Cathlamet, Wash, Road Work	Apr. 24
May 2.	Colville, Wash., Irrigation	May 1
May 2.	Enumclaw, Wash., Street Work	May 1
May 2.	Ephrata, Wash., Road Work	Apr. 24
May 2.	Mt. Vernon, Wash., Bridge	Apr. 17
May 2.	Salt Lake City, Utah, Street Work	Apr. 17
May 2.	Seattle, Wash., Road Work	Apr. 17
May 2.	Watts, Cal., Street Work	May 1
May 3.	Astoria, Ore., Bridges	May 1
May 3.	Grants Pass, Ore., Bridge	May 1
May 3.	Powell, Wyo., Irrigation	Apr. 17
May 3.	Riverside, Cal., Culverts	May 1
May 3.	San Francisco, Cal., Building	May 1
May 3.	Stockton, Cal., Street Work	Apr. 17
May 4.	Napa, Cal., Road Work	Apr. 24
May 4.	Oakland, Cal., Street Work	May 1
May 4.	Sacramento, Cal., Street Work	May 1
May 4.	San Francisco, Cal., Buildings	May 1
May 4.	San Luis Obispo, Cal., Bridge	Apr. 10
May 5.	Fort Shaw, Mont., Irrigation	Apr. 24
May 5.	Seattle, Wash., Bridge	May 1
May 5.	Stockton, Cal., Street Work	May 1
May 6.	Goldendale, Wash., Bridges	May 1
May 6.	Taft, Cal., Building	May 1
May 6.	Yreka, Cal., Buildings	Apr. 17
May 8.	Eugene, Ore., Bridges	May 1
May 8.	Los Angeles, Cal., Viaduct	Apr. 24
May 8.	Nelson, Cal., Building	Apr. 24
May 8.	North Yakima, Wash., Road Work	Apr. 24
May 8.	Olympia, Wash., Road Work	May 1
May 8.	Palo Alto, Cal., Road Work	May 1
May 8.	Sacramento, Cal., Building	Apr. 24
May 8.	Seattle, Wash., Road Work	Apr. 24
May 9.	Eureka, Cal., Bridge	Apr. 24
May 9.	Eureka, Cal., Road Work	May 1
May 9.	Modesto, Cal., Bridge	Apr. 17
May 9.	Modesto, Cal., Building	Apr. 17
May 10.	Los Angeles, Cal., Dredging	Apr. 17
May 10.	San Francisco, Cal., Fuel	Apr. 17
May 10.	Ventura, Cal., Bridge	Apr. 24
May 15.	Bakersfield, Cal., Building	May 1
May 15.	Colfax, Wash., Road Work	May 1
May 15.	Fort Huachuca, Ariz., Buildings	Apr. 24
May 15.	Martinez, Cal., Building	May 1
May 15.	Oakland, Cal., Road Work	May 1
May 15.	Oatman, Ariz., Water System	Mar. 20
May 15.	Washington, D. C., Irrigation	May 1
May 16.	Salt Lake City, Utah, Sewer	May 1
May 16.	Seattle, Wash., Road Work	May 1
May 18.	San Francisco, Cal., Buildings	May 1
May 19.	Ketchikan, Alaska, Coal, Oil, and Gas	Mar. 13
May 19.	Seattle, Wash., Building	May 1
May 20.	Cordova, Alaska, Buildings	Apr. 17
May 22.	Fort Laramie, Wash., Irrigation	May 1
May 22.	Oakland, Cal., Road Work	May 1
May 23.	Grand Junction, Colo., Irrigation	May 1
May 23.	Sacramento, Cal., Sewer	May 1
May 23.	Wenatchee, Wash., Irrigation	May 1
May 25.	St. Ignatius, Mont., Irrigation	May 1
May 27.	Washington, D. C., Building	May 1
May 31.	Aberdeen, Wash., Irrigation	May 1
June 15.	Anchorage, Alaska, Miscellaneous	Apr. 10

Building Permits

APRIL 20

Two Story Frame Dwelling—Cost $2900. E. Erickson, owner. S Caselli 603 W Douglass.

Two Story Frame Dwelling—Cost $2900. E. Erickson, owner. S Caselli 628 W Douglass.

Two Story Frame Flats—Cost $5700. W. Sattler, owner. E 5th Ave 125 N Clement.

Garage Alterations—Cost $3788. Alfred Hampton, owner. SW Downey and Frederick.

Cafeteria Alterations—Cost $5000. Boos Bros., owners. 725 Market.

Two Story Frame Dwelling—Cost $4000. McArthur Bros., owners. W 21st Ave 25 S Judah.

Three Story Frame Flats—Cost $5600. C. M. Harnett, owner. NW Glover and Jones.

APRIL 21

Three Story Class 'A' Office Building—Cost $40,000. D. Ghirardelli Co., owners. NW Larkin and North Point.

Three Story Class 'C' Garage and Residence—Cost $20,000. D. Ghirardelli Co., owners. W Larkin bet North Point and Beach.

One Story Class 'A' Power-House—Cost $15,000. D. Ghirardelli Co., owners. SE Beach and Polk.

Two Story Frame Dwelling—Cost $5000. Pockman & Co., owners. SE Clement and 40th Ave.

Two Story Frame Dwelling—Cost $2800. Wm. Klute, owner. W 24th Ave 340 N Balboa.

Two Story Frame Flats—Cost $4900. A. C. Hurrell, owner. E 10th Ave 300 S Balboa.

Two Story Frame Dwelling—Cost $4750. Allen & Co., owners. W 28th Ave 156 N California.

Two Story Frame Flats—Cost $5000. Anderson & Johnson, owners. W 9th Ave 350 S Cabrillo.

APRIL 24

Two Story Frame Dwelling—Cost $5000. W. H. Kiler, owner. Forest Hill Block 2126 Lot No 2.

Two Story Frame Dwelling—Cost $6000. W. H. Kiler, owner. Forest Hill Block 2128 Lot No 5.

Three Story Frame Tenements—Cost $13,000. H. Scholten, owner. E Mission 200 S 14th.

Two Story Frame Flats—Cost $6000. Oscar Heyman & Bro., owners. SW Lincoln Way and 22nd Ave.

APRIL 25

Two Story Frame Dwelling—Cost $3250. J. M. Schlesinger, owner. SW Seward 178 NE Corwin.

Three Story Frame Tenements—Cost $8500. Mrs. Hulda Petersen, owner. W 4th Ave 200 N Geary.

Three Story Frame Flats—Cost $5250. G. Figoni, owner. W Mason 120 N Union.

One Story Frame Dwelling—Cost $2800. J. H. Thorup, owner. E 24th Ave 50 N Balboa.

One Story Frame Dwelling—Cost $2350. Alice E. Kentzel, owner. E 24th Ave 100 N Balboa.

Three Story Frame Tenements—Cost $10,000. Elizabeth Petersen, owner. NW Cabrillo and Ninth Ave.

Two Story Frame Flats—Cost $5000. J. H. Plattner, owner. E 9th Ave 56 N Lawton.

Two Story Frame Tenements—Cost $13,500. J. A. Rutherford, owner. SW Lincoln Way and 3rd Ave.

APRIL 26

One Story Concrete Office—Cost $4000. Judson Manufacturing Co., owner. S Folsom 150 W 4th.

Pile Driving—Cost $4000. Jean Allec, owner. W Folsom 198 S 17th.

Two Story Frame Dwelling—Cost $9000. S. Erlanger, owner. Forest Hill Block 16 Lots 12 and 13.

Three Story Frame Flats—Cost $8500. G. Torre, owner. SE Taylor and Union.

Two Story Frame Residence—Cost $3984. Mrs. Mary Quinn, owner. W 10th Ave 100 N Lawton.

Two Story Frame Dwelling—Cost $4750. Irene Sullivan, owner. W San Benito 115 N St. Francis Blvd.

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